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DAILY DEVELOPMENT OF KERNELS OF HANNCHEN BARLEY FROM FLOWERING TO MATURITY AT ABERDEEN, IDAHO[1]

By HARRY V. HARLAN

Agronomist in Charge of Barley Investigations, Office of Cereal Investigations, Bureau of Plant Industry, United States Department of Agriculture

INTRODUCTION

Several years ago the author made a few elementary experiments on the function of the awn in barley. In these studies the awns were clipped from some spikes and not from others. The effect on the development of the kernels was so striking that in 1915 a more elaborate experiment was carried out by the author and Stephen Anthony. The development of kernels on normal and clipped spikes was determined from flowering to maturity. The method of study proved so satisfactory that it led to other investigations in which it offered the same possibility of application. The development of barley on dry land and on irrigated land, the response to irrigation water, and the differences in varietal behavior have all been studied by this means. The last study has been undertaken since the resignation of Mr. Anthony. In these studies, kernel growth has been used as an index of effect. Yield and size of mature kernels, while probably a safe summary of the effects of variations of treatment or differences of types, do not throw much light on the time when the effect occurred, or always on the reasons therefor. This group of studies has been carried on with the idea that variations from a basic growth curve showing the inception, duration, and degree of response would be much more illuminating than the single observation of the final result.

A number of studies have been completed, and it is the intention to publish the results of the special projects from time to time. The results represent a normal growth curve. It is intended that this curve shall form the basis of comparison in the later studies and that it shall

[1] These studies were made on the Aberdeen Substation, Aberdeen, Idaho, in connection with cereal experiments conducted cooperatively by the Idaho Agricultural Experiment Station and the Office of Cereal Investigations, Bureau of Plant Industry, United States Department of Agriculture.

be a connecting link between the various studies. In this paper the results with the Hannchen variety are given in full for one year at Aberdeen, Idaho. The Hannchen variety was chosen for this basic statement because it has been used more extensively than any other variety. The growth at Aberdeen is selected both because of the fact that most of the studies made and projected are located there and because of the remarkable uniformity of growth of plants at that place from season to season. In three different years the period from flowering to maturity has extended over exactly 26 days. This uniformity, coupled with accurate sampling, has made it possible to take samples at intervals as short as 24 hours or even less and still show consistent growth. In no previous studies on cereal crops, either here or abroad, have samples been taken more frequently than at 3-day intervals, yet it is readily seen in figure 1 that most of the growth in length is completed in a period of three days. The measurements of kernel dimensions are an important index of development which seems to have been generally ignored.

HISTORICAL REVIEW

The published data on kernel development have little relation to the various lines of investigation at Aberdeen, Idaho. Differences of location and variety make anything but general comparisons difficult in this connection.

The studies of kernel development previously reported in the cereals have been the outcome of a wide range of experiments and are too numerous to be reviewed in detail. Kudelka (*4*),[1] Lermer and Holzner (*5*), and many others have published on the origin and development of tissues in the caryopsis as a whole, or even in the entire plant. Some investigations have been specifically devoted to tissues of the pericarp. Johannsen (*3*), Brenchley (*1*), Schjerning (*6*, *7*), and numerous others have investigated the chemical changes of growth and maturation. The work of these investigators is referred to later. Their experiments were carried on under relatively unfavorable conditions. The contrast is remarkable between the humid climates of Denmark and England, with their frequent storms and days of low activity, and the arid climate of Aberdeen. Schjerning had a difference of 12 days in the maturity of his plots in two succeeding years.

The detail of the experiment at Aberdeen is more nearly like those of Brenchley (*1*), Schjerning (*6*, *7*), and Johannsen (*3*) than those of the other investigators. It differs from these in a reduction of the period between samples and in the extensive study of the physical indices of length and diameter of kernel. The chemical and morphological phases are not comparable with those of Schjerning and Johannsen.

[1] Reference is made by number (italic) to "Literature cited," p. 429.

EXPERIMENTAL METHODS

Such success as has been obtained in reducing the interval of sampling is due in large part to the accuracy of tagging spikes at the same stage of development. This, in turn, rests on an observation made several years

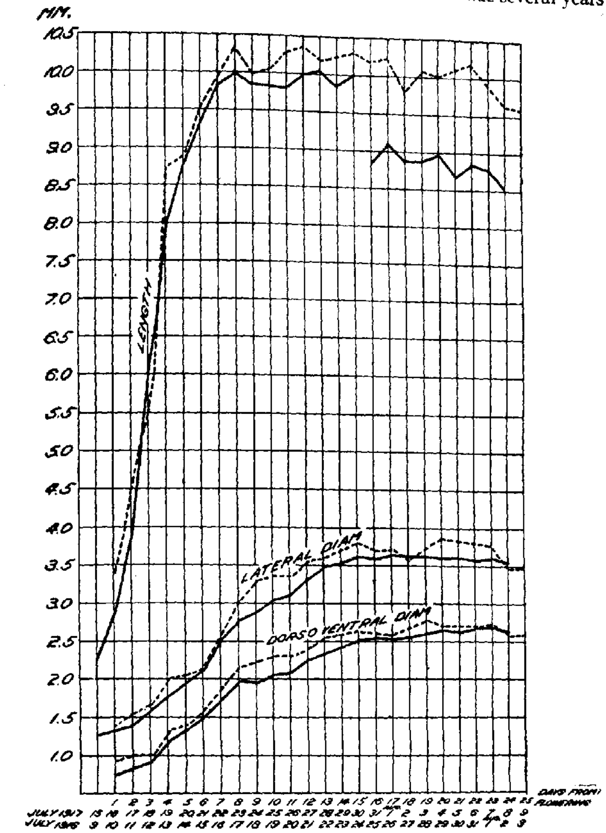


FIG. 1.—Graph showing length, lateral diameter, and dorsoventral diameter of barley kernels for the 25 days following flowering. The broken lines give the data for 1916, the solid lines the data for 1917.

before the work was started. In agronomic notes taken upon cereal varieties, the time of heading and the time of ripening have always been considered to be important statements of development. Of these, the time of heading is thought to be especially valuable, because drouth and other climatic factors that greatly influence maturity have usually affected the plant but little up to this stage.

While time of heading in barley is doubtless significant, it is very difficult to determine. A barley spike may be visible two or three days before it is fully exserted from the sheath. In some varieties the spikes are never completely exserted. In a study of this difficulty it was noticed that the emergence of the awns offered opportunity for a tangible observation. Upon trial it was found to be a very accurate index of the stage of the development of the spike. With the observation as a basis, spikes tagged as uniform before flowering were of so nearly the same stage of development that, despite individual fluctuations, growth in as short periods as 12 hours was evident in the data for many days; and almost until maturity the individual variations in samples of only two spikes did not obscure the growth in 24-hour periods. The accuracy of the method and the spectacular uniformity of Idaho seasons is well shown in figure 2, where the percentages of moisture in kernels in the seasons of 1916 and 1917 essentially coincide throughout the entire period of growth.

Three or four days after the tips of the awns are visible on the earliest culms a large number of culms are to be found with tips visible. At this time the plots are carefully inspected and the requisite number of culms is marked. The marking is done by tying a piece of wool yarn about the culm. Culms are selected in which the awns are protruding ¼ to ½ inch above the sheath of the uppermost leaf. A sufficient number of culms is tagged to insure against accident. As soon as the spikes are partially exserted a sample is taken. This sample and the one on the following day usually have several florets which have not yet been fertilized. The samples taken in the first few days consist of three spikes in order to secure a greater quantity of material, but later the number is reduced to two per sample. In most cases only one sample is taken each day, but in the cases furnishing the data reported in Table I two samples were taken, one in the morning and one in the evening. The samples are taken in the field by cutting the culms near the ground. These culms and spikes are wrapped in a moist towel and taken to the laboratory. As a protection against evaporation in the laboratory the spikelets are removed one at a time, the remainder of the spike being left in the towel. To secure the data rapidly and satisfactorily two men work on the same sample. The kernels are taken from the florets by the operator of the calipers, who measures the length, lateral diameter, and dorsoventral diameter in tenths of millimeters and records these measurements. The kernels are then passed to the operator of the balance and weighed to tenths of milligrams. Only the kernels on a single side of each spike are measured and weighed individually. The kernels of the other side of the spike are added to those measured individually and weighed to obtain a larger sample. These are placed in small vials and dried in a water-jacket oven. The vials are then corked, and the material is preserved for later analysis.

EXPERIMENTAL MATERIAL

Most of the data presented herein were obtained in 1917, but many of the graphs contain curves of the data for 1916 as well. The curves for 1916 are added merely for comparison and to give an idea of the

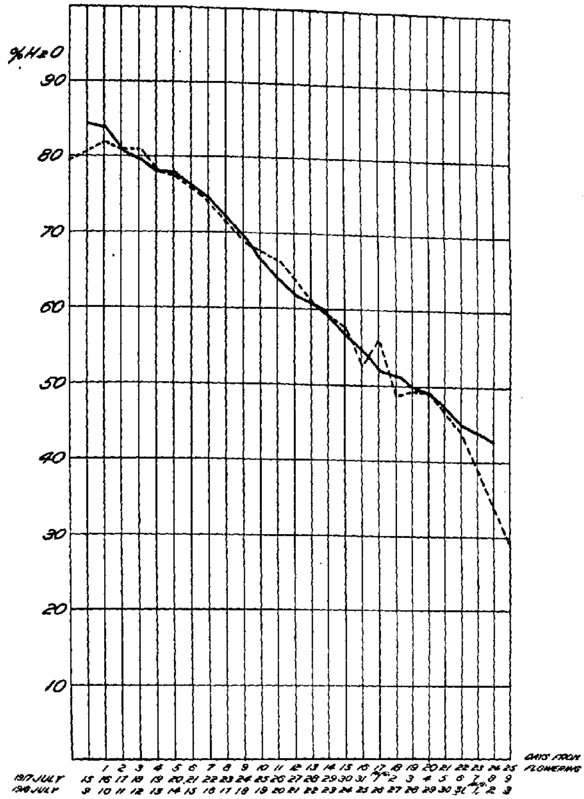


FIG. 2.—Graph showing percentage of moisture per kernel from date of flowering. The broken line gives the data for 1916, the solid line the data for 1917.

range of annual fluctuations. The larger growth in 1916 was due, doubtless, to the more generous application of water in that year. The plots were in flower a week earlier in 1916 than in 1917 and may have had some advantage of season. In figure 3 the maximum and mean temperatures for the two years are shown. These are of interest later in their relation to daily fluctuation. In both years the barley was

grown under irrigation and was watered sufficiently often to insure a satisfactory growth. In 1916, only one sample was taken per day, and no samples were taken on Sunday. In 1917, samples were taken morning and evening, on Sundays as well as on week days; and the series is thus more nearly complete than in the previous year.

DAILY INCREMENT OF VOLUME

The data on the daily increment of volume, as shown by the increased length, lateral diameter, dorsoventral diameter, and wet weight of kernels, fall into two classes, which will be treated separately. The measurements

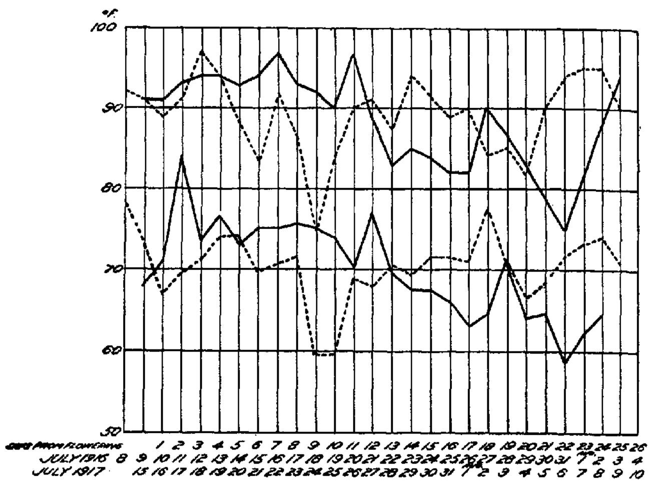


FIG. 3.—Graph showing maximum and mean daily temperatures recorded at Aberdeen, Idaho, from July 8 to August 4, 1916 (broken line), and from July 15 to August 10, 1918 (solid line). In both years these temperatures are for 26 days following flowering of Hannchen barley.

of volume are observations immediately obtainable in the field and will be first reported. The chemical constituents of the kernels are determined in the laboratory and will be referred to later.

Table I shows the weights and measurements of the individual kernels on one side of each spike in the samples. The samples were taken at approximately 6 a. m. and 7 p. m. These hours marked the beginning and the end of effective sunshine. The morning samples on each date are on the left half of the table and evening samples on the right half. The florets are numbered from the base of the spike toward the tip, so that the figures in each column represent a spike with the base toward the top of the page. In the earlier samples where three spikes were taken, the record of one spike has been omitted from this table because of lack of space. While the number of data makes it difficult

to visualize the changes that take place from day to day, the nature of the individual spikes can be seen only in this table. The averages do not give a correct indication of the condition of a single spike. The variations between kernels are reduced by averages, and the difficulty of securing such averages is not apparent in the absence of the complete data. It is readily seen in the table that in instances where the spike is short it is often a question which kernel should be considered the third or the fourth. Such decisions affect the averages, and they must be made by some arbitrary method, since the actual number of sterile nodes at the base can not be used successfully as a basis. The curve of the kernels of a single spike usually is better than the average of two spikes unless the two spikes have the same number of kernels. The extremes of the curves are especially liable to distortion in averages. Of course, the curve of the growth by days is much improved by the use of averages. The same process that reduces the fluctuation in the record of a spike increases the gap between samples.

TABLE I.—*Normal growth of Hannchen barley in 12-hour periods from flowering to maturity, at Aberdeen, Idaho, in 1917*

JULY 15

Kernel No. from base of spike.	6 a. m.								7 p. m.							
	Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorso-ventral diameter of kernel on spike—		Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorso-ventral diameter of kernel on spike—	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
	Gm.	Gm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Gm.	Gm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.
1	....	....	.....	.....	.....	.....	.....	.....	[a]S	S	S	S	S	S	S	S
2	....	....	.....	.....	.....	.....	.....	.....	[b]0.0005	[b]0.0007	1.9	1.9	.....	.....	.....	.....
3	....	....	.....	.....	.....	.....	.....	.....	[b].0012	.0013	1.9	2.0	.....	.....	.....	.....
4	....	....	.....	.....	.....	.....	.....	.....	.0014	.0015	2.1	2.2	1.2	1.2	.....	.....
5	....	....	.....	.....	.....	.....	.....	.....	.0018	.0020	2.1	2.4	1.2	1.2	.....	.....
6	....	....	.....	.....	.....	.....	.....	.....	.0020	.0020	2.2	2.3	1.3	1.2	.....	.....
7	....	....	.....	.....	.....	.....	.....	.....	.0022	.0025	2.5	2.7	1.3	1.3	.....	.....
8	....	....	.....	.....	.....	.....	.....	.....	.0025	.0026	2.5	2.8	1.4	1.3	.....	.....
9	....	....	.....	.....	.....	.....	.....	.....	.0027	.0026	2.7	2.6	1.4	1.3	.....	.....
10	....	....	.....	.....	.....	.....	.....	.....	.0026	.0027	2.5	2.7	1.3	1.2	.....	.....
11	....	....	.....	.....	.....	.....	.....	.....	.0023	.0025	2.3	2.6	1.3	1.3	.....	.....
12	....	....	.....	.....	.....	.....	.....	.....	.0019	.0019	2.2	2.3	1.2	1.3	.....	.....
13	....	....	.....	.....	.....	.....	.....	.....	.0014	.0014	2.1	2.3	1.2	1.1	.....	.....
14	....	....	.....	.....	.....	.....	.....	.....	....	[b].0005	.....	1.0	.....	.....	.....	.....

JULY 16

Kernel No.	Weight A (6 a. m.)	Weight B	Length A	Length B	Lateral A	Lateral B	Dorso-ventral A	Dorso-ventral B	Weight A (7 p. m.)	Weight B	Length A	Length B	Lateral A	Lateral B	Dorso-ventral A	Dorso-ventral B
1	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
2	0.0011	[b]0.0005	2.0	1.6	.....	.....	.....	.....	S	S	S	S	S	S	S	S
3	.0022	.0014	2.6	2.0	1.3	1.2	.....	.....	0.0009	0.0007	1.9	1.6	1.3	0.8	0.6	0.5
4	.0019	.0020	2.4	2.4	1.3	1.2	.....	0.7	.0028	.0012	3.1	1.8	1.4	1.1	.8	.6
5	.0020	.0025	2.3	2.5	1.3	1.3	.....	.8	.0031	.0018	3.0	2.2	1.4	1.2	.8	.7
6	.0023	.0032	2.4	3.0	1.3	1.4	.....	.8	.0033	.0025	3.4	2.5	1.3	1.3	.8	.7
7	.0024	.0032	2.5	3.2	1.3	1.4	0.7	.8	.0042	.0029	3.7	3.0	1.4	1.4	.8	.8
8	.0028	.0033	2.7	3.2	1.3	1.3	.8	.8	.0041	.0028	3.7	3.0	1.4	1.4	.8	.7
9	.0030	.0035	3.2	3.3	1.4	1.4	.8	.8	.0045	.0030	4.0	3.1	1.4	1.4	.8	.8
10	.0029	.0039	2.7	3.6	1.3	1.4	.8	.8	.0043	.0030	4.0	3.0	1.3	1.4	.8	.8
11	.0027	.0036	2.9	3.2	1.3	1.5	.7	.8	.0039	.0023	4.0	2.4	1.4	1.2	.8	.7
12	.0023	.0029	2.6	3.1	1.4	1.3	.7	.7	.0029	S	3.4	S	1.3	S	.7	S
13	.0017	.0018	2.3	1.9	1.1	1.3	.5	.7	....	....	.....	.....	.....	.....	.....	.....

[a] The letter S indicates a sterile spikelet.

[b] Unfertilized.

TABLE I.—*Normal growth of Hannchen barley in 12-hour periods from flowering to maturity, at Aberdeen, Idaho, in 1917*—Continued

Kernel No. from base of spike.	6 a. m.								7 p. m.							
	Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorso-ventral diameter of kernel on spike—		Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorso-ventral diameter of kernel on spike—	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
	Gm.	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
JULY 17																
1	....	....	.....	.....	.....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....
2	....	0.0012	.....	2.1	.....	1.0	.....	0.6	0.0029	0.0033	2.8	3.5	1.4	1.4	0.8	0.8
3	0.0022	.0023	2.4	2.6	1.2	1.3	0.7	.7	.0045	.0051	3.6	3.9	1.3	1.4	.8	.8
4	.0025	.0030	2.7	3.2	1.2	1.3	.7	.8	.0055	.0052	4.4	4.2	1.4	1.5	.9	.9
5	.0033	.0034	2.9	3.3	1.3	1.4	.8	.8	.0058	.0056	4.6	4.8	1.6	1.5	.9	.9
6	.0033	.0037	3.0	3.5	1.4	1.4	.8	.8	.0061	.0064	4.9	5.0	1.3	1.4	.9	.9
7	.0038	.0039	3.1	3.7	1.5	1.4	.9	.8	.0069	.0071	5.0	5.5	1.4	1.4	.9	.9
8	.0036	.0043	3.5	3.8	1.5	1.4	.9	.9	.0076	.0067	5.6	5.5	1.4	1.5	.9	.9
9	.0038	.0048	3.2	4.3	1.4	1.5	.9	.9	.0062	.0068	4.7	5.6	1.6	1.5	.8	.9
10	.0038	.0043	3.4	4.1	1.5	1.3	.9	.8	.0071	.0069	5.7	5.5	1.5	1.5	.9	.9
11	.0029	.0036	3.1	3.7	1.3	1.3	.8	.8	.0067	.0062	5.4	5.1	1.4	1.5	.9	.8
12	.0031	.0029	3.0	3.4	1.4	1.3	.8	.7	.0057	.0050	4.8	4.7	1.4	1.4	.8	.8
13	.0025	....	2.8	.....	1.3	.....	.8	.....	....	.0028	.....	2.9	.....	1.3	.....	.7
14	.0018	....	2.1	.....	1.3	.....	.6	.....	....	....	.....	.....	.....	.....	.....	.....
JULY 18																
1	....	....	.....	.....	.....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....
2	0.0046	0.0035	3.8	3.6	1.5	1.3	0.9	0.8	0.0048	0.0054	4.0	4.5	1.5	1.5	0.7	0.8
3	.0076	.0047	5.2	4.0	1.6	1.4	.9	.9	.0073	.0075	5.6	5.6	1.5	1.6	.8	.9
4	.0088	.0056	6.3	4.6	1.6	1.4	.9	.9	.0079	.0086	5.9	6.1	1.6	1.6	.8	.9
5	.0094	.0060	6.4	4.7	1.6	1.4	.9	.9	.0083	.0089	6.3	6.9	1.6	1.7	.9	.9
6	.0095	.0067	6.8	5.4	1.5	1.6	.9	.9	.0082	.0095	6.2	6.7	1.6	1.6	.9	1.0
7	.0100	.0075	6.9	5.9	1.6	1.5	.9	.9	.0098	.0096	7.0	6.8	1.6	1.7	1.0	1.0
8	.0097	.0079	7.1	6.1	1.6	1.6	1.0	.9	.0102	.0108	7.0	7.5	1.7	1.6	1.0	1.1
9	.0093	.0076	6.8	5.9	1.6	1.5	.9	.9	.0104	.0092	7.4	6.9	1.7	1.7	1.0	1.0
10	.0089	.0074	6.8	5.9	1.6	1.5	.9	.8	.0096	.0090	7.3	6.6	1.6	1.6	1.0	.9
11	.0089	.0073	6.5	5.9	1.5	1.5	.8	.8	.0083	.0086	6.7	6.5	1.6	1.6	.9	.9
12	.0068	.0064	6.0	5.5	1.5	1.5	.8	.8	.0075	.0068	6.3	5.7	1.6	1.6	.8	.8
JULY 19																
1	0.0023	....	2.8	.....	1.3	.....	0.7	.....	....	....	.....	.....	.....	.....	.....	.....
2	.0070	0.0050	5.5	4.8	.5	1.5	.8	0.8	0.0100	0.0084	7.0	6.2	1.7	1.7	1.0	0.9
3	.0091	.0090	6.4	6.6	1.7	1.6	.9	.9	.0125	.0109	8.0	7.3	1.8	1.7	1.2	1.0
4	.0100	.0108	6.7	7.7	1.7	1.7	1.0	1.1	.0142	.0122	8.7	8.1	1.8	1.8	1.2	1.0
5	.0114	.0128	7.9	8.3	1.7	1.7	1.1	1.2	.0151	.0131	9.0	8.3	1.9	1.7	1.2	1.2
6	.0123	.0132	8.3	8.2	1.8	1.8	1.1	1.3	.0160	.0136	9.1	8.4	1.9	1.8	1.3	1.3
7	.0128	....	8.0	.....	1.8	.....	1.2	.....	.0170	.0149	9.3	8.8	2.0	1.9	1.3	1.3
8	.0129	.0151	8.3	8.5	1.8	1.8	1.1	1.3	.0166	.0146	9.3	8.7	1.9	1.9	1.4	1.3
9	.0127	.0156	8.0	8.6	1.8	2.0	1.2	1.4	.0154	.0160	8.8	8.9	1.9	1.9	1.3	1.3
10	.0124	.0153	8.2	8.7	1.8	2.0	1.1	1.3	.0157	.0150	8.8	8.8	1.8	1.9	1.2	1.2
11	.0116	.0141	7.8	8.2	1.7	1.9	1.1	1.4	.0147	.0138	8.5	8.8	1.8	1.8	1.2	1.2
12	.0102	.0132	7.7	8.0	1.7	1.8	1.0	1.2	....	.0108	.....	7.8	.....	1.6	.....	1.1
13	.0082	.0115	6.5	7.5	1.6	1.8	1.0	1.1	....	....	.....	.....	.....	.....	.....	.....
JULY 20																
1	....	0.0060	.....	5.6	.....	1.6	.....	0.8	....	0.0046	.....	4.9	.....	1.4	.....	0.6
2	0.0098	.0133	7.1	8.0	1.8	1.9	1.0	1.2	0.0099	.0132	7.0	8.3	1.7	1.8	1.0	1.1
3	.0107	.0163	7.3	9.0	1.8	1.9	1.1	1.3	.0107	.0145	7.1	8.8	1.8	1.9	1.0	1.2
4	.0138	.0176	9.0	9.0	1.9	2.0	1.2	1.4	.0136	.0178	8.2	9.4	1.9	2.0	1.2	1.4
5	.0150	.0178	9.0	9.0	1.9	2.0	1.3	1.4	.0151	.0192	9.0	9.6	1.9	2.1	1.2	1.5
6	.0170	.0188	9.5	9.1	2.0	2.1	1.3	1.5	.0162	.0200	8.8	9.9	2.0	2.2	1.2	1.5
7	.0177	.0198	9.1	9.7	2.0	2.2	1.3	1.6	.0165	.0204	8.8	9.7	2.0	2.2	1.3	1.5
8	.0174	.0208	9.5	9.7	1.9	2.1	1.3	1.5	....	.0196	.....	9.6	.....	2.1	.....	1.5
9	.0159	.0200	9.1	9.6	2.0	2.2	1.3	1.5	.0164	.0194	9.0	9.1	2.0	2.1	1.4	1.5
10	.0165	.0176	9.0	9.3	2.0	2.1	1.3	1.5	.0152	.0168	8.7	9.2	1.8	2.0	1.3	1.4
11	.0150	.0165	8.8	8.8	1.9	2.0	1.3	1.4	.0133	.0151	8.4	8.6	1.8	1.9	1.2	1.4
12	.0126	.0125	8.1	8.2	1.8	1.8	1.2	1.2	.0121	....	8.0	.....	1.7	.....	1.2	.....

TABLE I.—*Normal growth of Hannchen barley in 12-hour periods from flowering to maturity, at Aberdeen, Idaho, in 1917*—Continued

Kernel No. from base of spike.	6 a. m.								7 p. m.							
	Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorso-ventral diameter of kernel on spike—		Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorso-ventral diameter of kernel on spike—	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
	Gm.	Gm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Gm.	Gm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.
JULY 21																
1	....	....	.....	.....	.....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....
2	0.0093	0.0124	6.8	7.9	1.7	1.9	1.0	1.3	....	0.0193	.....	8.1	.....	1.9	.....	1.2
3	.0139	.0165	8.3	8.8	1.8	1.9	1.2	1.3	0.0157	.0179	8.7	9.3	2.0	2.1	1.4	1.5
4	.0170	.0184	9.1	9.3	2.0	1.9	1.3	1.5	.0199	.0209	9.4	9.5	2.2	2.1	1.5	1.4
5	.0181	.0202	9.0	9.6	2.0	2.1	1.4	1.5	.0210	.0225	10.0	9.7	2.1	2.2	1.5	1.6
6	.0182	.0195	9.3	9.6	2.1	2.1	1.4	1.4	.0227	.0250	10.0	10.4	2.1	2.3	1.6	1.7
7	.0195	.0209	9.4	10.0	2.0	2.0	1.5	1.5	.0230	.0257	10.1	10.2	2.2	2.4	1.6	1.6
8	.0199	.0216	9.3	10.0	2.1	2.1	1.5	1.6	.0218	.0236	9.8	10.1	2.2	2.4	1.5	1.7
9	.0195	.0206	9.5	9.6	2.0	2.0	1.5	1.5	.0248	.0275	10.0	10.0	2.3	2.5	1.7	1.8
10	.0170	.0186	8.9	9.4	1.9	1.9	1.5	1.6	.0216	.0233	10.1	9.8	2.3	2.3	1.5	1.7
11	.0158	.0169	8.8	.....	1.9	2.0	1.3	1.4	.0212	.0234	9.3	9.1	2.3	2.4	1.5	1.8
12	....	....	.....	.....	.....	.....	.....	.....	.0187	.0237	9.2	9.6	2.2	2.4	1.5	1.7
13	....	....	.....	.....	.....	.....	.....	.....	.0168	.0193	8.6	8.6	2.0	2.2	1.4	1.5
JULY 22																
1	....	....	.....	.....	.....	.....	.....	.....	....	0.0160	.....	8.9	.....	2.0	.....	1.5
2	0.0190	0.0200	9.2	9.6	2.2	2.3	1.4	1.5	0.0190	.0205	9.1	9.5	2.2	2.3	1.4	1.5
3	.0248	.0225	9.9	10.1	2.3	2.4	1.6	1.6	.0232	.0253	9.9	10.6	2.4	2.4	1.6	1.7
4	.0272	.0282	10.2	10.5	2.5	2.5	1.7	1.8	.0270	.0264	10.2	10.5	2.6	2.5	1.6	1.6
5	.0291	.0294	10.2	10.3	2.6	2.6	1.9	1.8	.0278	.0289	10.2	10.5	2.5	2.8	1.8	1.9
6	.0279	.0293	10.1	10.1	2.6	2.5	1.9	1.8	.0284	.0289	10.4	10.4	2.6	2.6	1.8	1.9
7	.0276	.0289	9.8	10.2	2.7	2.6	1.8	1.8	.0280	.0284	10.0	10.5	2.7	2.6	1.8	1.8
8	.0283	.0282	9.5	10.1	2.7	2.5	1.9	1.8	.0271	.0287	9.6	10.0	2.6	2.8	1.7	1.8
9	.0256	.0306	9.5	10.1	2.6	2.6	1.6	1.9	.0282	.0282	9.6	10.2	2.6	2.7	1.8	1.8
10	.0248	.0277	9.3	9.9	2.5	2.6	1.8	1.8	.0266	.0270	9.4	9.9	2.6	2.5	1.7	1.9
11	.0203	.0257	8.8	9.8	2.4	2.6	1.5	1.7	.0241	.0253	9.4	9.7	2.5	2.5	1.7	1.7
12	....	.0237	.....	9.6	.....	2.5	.....	1.7	.0217	.0258	8.9	10.0	2.3	2.6	1.6	1.7
13	....	.0195	.....	9.0	.....	2.3	.....	1.5	....	.0220	.....	8.8	.....	2.5	.....	1.7
JULY 23																
1	....	....	.....	.....	.....	.....	.....	.....	....	0.0084	.....	7.4	.....	1.7	.....	1.2
2	....	....	.....	.....	.....	.....	.....	.....	0.0265	.0223	9.9	10.0	2.7	2.3	1.7	1.5
3	0.0282	0.0219	10.0	9.3	2.8	2.3	1.8	1.7	.0321	.0270	10.3	10.0	2.8	2.7	1.8	1.8
4	.0333	.0270	10.2	10.1	2.7	2.6	1.9	1.8	.0335	.0316	10.1	10.2	3.0	2.7	2.0	1.9
5	.0363	.0294	10.3	10.5	3.0	2.7	2.0	1.9	.0359	.0249	10.3	9.5	3.0	2.7	1.9	1.9
6	.0373	.0316	10.3	10.5	3.1	2.8	2.2	2.0	.0359	.0308	10.6	10.2	3.0	2.8	2.0	1.9
7	.0340	.0334	9.9	10.5	3.0	2.9	1.9	1.9	.0352	.0320	10.7	10.1	2.8	2.8	2.0	2.0
8	.0354	.0334	10.1	10.3	2.9	2.9	2.0	2.0	.0372	.0334	10.6	10.0	3.0	2.8	2.1	1.9
9	.0339	.0312	9.9	9.7	2.8	2.8	2.1	1.9	.0343	.0298	9.9	9.9	3.0	2.8	2.0	1.8
10	.0294	.0300	9.4	10.3	2.8	2.8	1.8	1.9	.0348	.0319	10.0	10.1	3.1	2.9	2.0	1.8
11	.0292	.0309	9.3	9.7	2.8	2.8	1.9	2.0	.0315	.0291	9.6	9.5	2.9	2.8	1.9	1.8
12	.0246	.0275	8.6	9.5	2.6	2.6	1.8	1.8	.0299	.0250	9.7	9.1	2.9	2.6	2.0	1.8
JULY 24																
1	....	....	.....	.....	.....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....
2	0.0142	0.0212	8.4	9.0	2.3	2.4	1.4	1.5	....	0.0173	.....	8.5	.....	2.0	.....	1.6
3	.0285	.0302	9.9	10.2	2.3	2.8	1.7	1.8	0.0291	.0301	9.6	9.4	2.7	2.8	1.8	2.0
4	.0323	.0328	0.8	10.2	2.9	2.8	1.8	1.9	.0335	.0333	10.3	10.0	3.0	2.8	2.0	2.1
5	.0346	.0328	10.4	10.3	2.9	2.8	1.9	1.8	.0361	.0372	10.0	10.2	3.0	3.1	2.0	2.0
6	.0359	.0345	10.3	10.2	3.0	2.9	1.9	1.9	.0371	.0383	10.2	10.4	3.0	3.0	2.0	2.0
7	.0357	.0332	10.2	10.3	2.9	2.9	1.8	2.0	.0353	.0387	10.0	10.2	2.9	3.0	2.0	2.2
8	.0355	.0342	9.9	10.2	2.9	2.8	2.0	2.0	.0379	.0381	10.1	10.2	3.0	3.2	2.0	2.0
9	.0328	.0340	9.8	10.4	3.0	2.8	1.8	2.0	.0322	.0398	10.1	10.0	2.9	3.1	1.9	2.0
10	.0342	.0333	9.1	9.9	3.0	2.9	1.9	2.1	.0338	.0384	9.6	10.1	2.8	3.1	1.9	2.0
11	.0319	.0328	9.4	10.2	3.0	2.9	1.6	2.0	.0344	.0363	9.3	9.8	3.0	3.0	2.0	2.1
12	.0276	.0304	9.0	9.7	2.9	2.8	1.8	2.0	.0278	.0351	9.3	9.6	2.8	2.9	2.0	1.9
13	....	.0284	.....	8.8	.....	2.8	.....	1.9	....	.0325	.....	9.9	.....	2.8	.....	1.8

TABLE I.—*Normal growth of Hannchen barley in 12-hour periods from flowering to maturity, at Aberdeen, Idaho, in 1917*—Continued

JULY 25

Kernel No. from base of spike.	6 a. m. Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorso-ventral diameter of kernel on spike—		7 p. m. Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorso-ventral diameter of kernel on spike—	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
	Gm.	Gm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Gm.	Gm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.
1	....	....	.....	.....	.....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....
2	0.0125	0.0092	7.5	7.4	1.7	1.5	1.4	1.0	0.0134	....	7.8	.....	2.3	.....	1.5	.....
3	.0356	.0273	9.9	9.2	3.0	2.6	2.0	1.8	.0318	0.0307	9.6	9.8	3.0	2.9	1.8	2.0
4	.0386	.0308	10.5	9.8	3.1	2.8	2.2	1.9	.0391	.0359	10.2	10.5	3.3	3.0	2.1	2.0
5	.0449	.0366	10.3	10.4	3.3	3.1	2.3	2.0	.0387	.0387	10.0	10.4	3.2	3.2	2.2	2.1
6	.0445	.0377	10.3	10.3	3.3	3.0	2.2	2.1	.0388	.0397	10.1	10.4	3.2	3.2	2.3	2.0
7	.0440	.0367	10.3	10.1	3.2	3.0	2.2	2.1	.0390	.0386	10.0	10.0	3.3	3.2	2.1	2.0
8	.0357	.0394	9.8	10.6	3.0	3.1	1.9	1.9	.0400	.0409	9.9	10.2	3.3	3.2	2.3	2.1
9	.0438	.0384	9.9	10.2	3.4	3.0	2.3	2.1	.0384	.0390	9.5	9.7	3.3	3.1	2.3	2.0
10	.0349	.0378	9.8	10.0	2.9	2.9	2.1	2.0	.0358	.0371	9.4	9.9	3.2	3.1	2.1	2.1
11	.0388	.0374	9.4	10.2	3.3	3.0	2.2	2.1	.0334	.0333	9.1	9.3	3.0	3.1	2.1	2.1
12	.0343	.0350	9.1	9.8	3.0	2.9	2.0	2.1	.0314	....	9.0	.....	3.0	.....	2.0	.....
13	....	.0332	.....	9.2	.....	3.1	.....	2.1	....	....	.....	.....	.....	.....	.....	.....

JULY 26

Kernel No. from base of spike.	6 a. m. Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorso-ventral diameter of kernel on spike—		7 p. m. Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorso-ventral diameter of kernel on spike—	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
1	....	....	.....	.....	.....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....
2	0.0271	0.0305	9.5	9.4	2.4	2.8	1.7	1.9	0.0206	0.0174	8.3	8.5	2.5	2.4	1.6	1.4
3	.0346	.0320	9.8	9.5	2.8	2.6	1.8	1.8	.0406	.0399	10.1	10.0	3.3	3.4	2.0	2.0
4	.0407	.0395	10.4	10.1	3.2	3.0	2.1	2.0	.0445	.0420	10.3	9.9	3.4	3.3	2.0	2.2
5	.0419	.0418	10.5	9.9	3.2	3.1	2.1	2.2	.0445	.0451	10.4	9.8	3.3	3.3	2.4	2.0
6	.0403	.0408	10.1	9.7	3.1	3.2	2.1	2.1	.0445	.0450	10.4	10.2	3.3	3.3	2.2	2.1
7	.0359	.0398	10.2	9.9	2.8	3.2	2.1	2.2	.0406	.0457	9.8	9.4	3.2	3.3	2.1	2.3
8	.0400	.0400	10.0	10.0	3.1	3.0	2.2	2.2	.0436	.0443	10.2	10.1	3.4	3.3	2.2	2.4
9	.0366	.0378	9.7	9.2	3.4	3.1	2.1	2.2	.0428	.0416	10.4	9.8	3.3	3.4	2.2	2.3
10	.0358	.0375	10.0	9.5	3.0	3.1	1.8	2.0	.0409	.0422	10.2	9.6	3.2	3.4	2.1	2.3
11	.0335	.0269	9.5	8.5	3.2	2.6	2.0	1.9	.0360	.0397	9.4	9.4	3.2	3.3	2.1	2.0
12	....	....	.....	.....	.....	.....	.....	.....	....	.0336	.....	8.9	.....	2.9	.....	2.0

JULY 27

Kernel No. from base of spike.	6 a. m. Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorso-ventral diameter of kernel on spike—		7 p. m. Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorso-ventral diameter of kernel on spike—	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
1	....	....	.....	.....	.....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....
2	0.0194	0.0387	8.2	10.2	3.5	3.2	1.5	2.1	0.0346	....	9.6	.....	3.0	.....	2.2	.....
3	.0405	.0479	10.0	10.6	3.1	3.2	1.9	2.2	.0431	0.0406	9.8	9.9	3.1	3.3	2.2	2.2
4	.0417	.0489	10.4	10.6	3.5	3.5	2.1	2.2	.0479	.0436	10.7	10.3	3.4	3.3	2.1	2.2
5	.0499	.0481	10.6	10.5	3.4	3.4	2.3	2.4	.0467	.0498	10.8	10.1	3.3	3.4	2.0	2.3
6	.0495	.0483	10.4	10.4	3.4	3.5	2.3	2.4	.0483	.0514	10.5	10.7	3.2	3.3	2.3	2.4
7	.0501	.0483	10.3	10.4	3.4	3.5	2.2	2.2	.0497	.0491	10.5	9.5	3.4	3.2	2.5	2.3
8	.0498	.0465	10.2	10.1	3.4	3.4	2.3	2.1	.0498	.0499	10.4	10.1	3.3	3.5	2.2	2.5
9	.0487	.0445	10.2	10.1	3.3	3.3	2.3	2.3	.0465	.0481	10.3	10.2	3.3	3.5	2.2	2.4
10	.0480	.0440	9.9	9.9	3.4	3.2	2.5	2.4	.0479	.0435	10.0	10.1	3.5	3.2	2.4	2.2
11	.0443	.0430	9.8	9.5	3.3	3.4	2.5	2.3	.0455	.0429	10.0	9.5	3.4	3.3	2.4	2.2
12	.0435	.0408	9.2	9.5	3.3	3.0	2.3	2.4	.0433	.0324	9.8	8.7	3.4	2.7	2.3	2.1
13	.0330	....	8.6	.....	3.0	.....	2.1	.....	.0392	....	9.3	.....	3.2	.....	2.3	.....
14	....	....	.....	.....	.....	.....	.....	.....	.0390	....	9.1	.....	3.3	.....	2.1	.....

JULY 28

Kernel No. from base of spike.	6 a. m. Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorso-ventral diameter of kernel on spike—		7 p. m. Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorso-ventral diameter of kernel on spike—	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
1	....	....	.....	.....	.....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....
2	....	0.0289	.....	8.5	.....	3.0	.....	1.9	0.0417	0.0359	10.0	9.9	3.4	3.2	2.1	1.9
3	0.0352	.0491	9.6	10.1	3.3	3.5	1.9	2.2	.0477	.0484	9.8	10.5	3.5	3.4	2.4	2.3
4	.0417	.0512	10.1	10.3	3.2	3.5	2.0	2.3	.0531	.0533	10.7	10.2	3.5	3.5	2.5	2.5
5	.0471	.0523	9.9	10.5	3.5	3.5	2.2	2.3	.0556	.0544	10.2	10.5	3.7	3.7	2.6	2.5
6	.0477	.0578	10.1	10.6	3.4	3.7	2.3	2.5	.0519	.0549	10.2	10.4	3.7	3.5	2.5	2.4
7	.0500	.0535	10.0	10.4	3.5	3.7	2.2	2.5	.0540	.0529	10.2	10.2	3.6	3.6	2.5	2.4
8	.0503	.0560	10.2	10.5	3.6	3.7	2.2	2.6	.0510	.0521	10.0	10.2	3.4	3.4	2.5	2.5
9	.0479	.0544	10.4	10.4	3.4	3.7	2.2	2.5	.0467	.0487	10.3	10.3	3.3	3.5	2.3	2.4
10	.0494	.0526	9.9	10.1	3.5	3.6	2.2	2.4	.0479	.0492	10.0	10.1	3.5	3.5	2.4	2.5
11	.0505	.0529	9.9	9.7	3.5	3.6	2.3	2.5	.0467	.0493	9.8	9.7	3.3	3.6	2.3	2.6
12	.0446	.0487	9.7	10.0	3.4	3.6	2.1	2.5	.0426	.0456	10.0	9.8	3.4	3.4	2.2	2.5
13	.0427	.0445	9.6	9.6	3.4	3.4	2.2	2.2	....	.0406	.....	9.2	.....	3.3	.....	2.3
14	.0395	.0390	9.4	9.0	3.3	3.2	2.3	2.2	....	....	.....	.....	.....	.....	.....	.....

TABLE I.—*Normal growth of Hannchen barley in 12-hour periods from flowering to maturity, at Aberdeen, Idaho, in 1917*—Continued

JULY 29

Kernel No. from base of spike.	6 a. m.								7 p. m.							
	Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorso-ventral diameter of kernel on spike—		Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorso-ventral diameter of kernel on spike—	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
	Gm.	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
2	0.0228	....	3.5	....	2.7	....	1.6	....	0.0377	0.0434	9.8	9.8	3.0	3.5	2.0	2.3
3	.0492	0.0385	9.6	9.7	3.4	3.3	2.3	2.0	.0507	.0482	10.0	9.8	3.6	3.5	2.5	2.5
4	.0513	.0485	9.3	10.3	3.7	3.5	2.4	2.1	.0532	.0537	10.1	10.3	3.6	3.5	2.5	2.5
5	.0550	.0502	10.4	10.3	3.7	3.6	2.5	2.4	.0537	.0532	10.1	10.0	3.5	3.6	2.5	2.5
6	.0550	.0496	9.6	10.2	3.8	3.6	2.5	2.4	.0538	.0522	10.3	10.3	3.5	3.7	2.5	2.4
7	.0504	.0511	10.0	9.8	3.4	3.7	2.2	2.5	.0514	.0513	9.7	10.1	3.4	3.5	2.5	2.4
8	.0492	.0497	10.1	10.3	3.4	3.4	2.3	2.3	.0521	.0522	10.1	10.1	3.6	3.6	2.6	2.6
9	.0487	.0506	9.9	9.8	3.6	3.5	2.6	2.5	.0520	.0492	9.9	10.4	3.4	3.5	2.6	2.5
10	.0498	.0485	9.4	10.0	3.7	3.5	2.5	2.5	.0465	.0502	9.4	9.7	3.4	3.6	2.4	2.6
11	.0465	.0446	9.6	9.6	3.5	3.4	2.3	2.4	.0448	.0418	9.2	8.7	3.4	3.4	2.4	2.4
12	.0406	.0405	9.0	9.0	3.3	3.3	2.4	2.4	....	....	....	....	....	....	....	....

JULY 30

Kernel No.	6 a. m. Weight A.	Weight B.	Length A.	Length B.	Lateral A.	Lateral B.	Dorso-ventral A.	Dorso-ventral B.	7 p. m. Weight A.	Weight B.	Length A.	Length B.	Lateral A.	Lateral B.	Dorso-ventral A.	Dorso-ventral B.
1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
2	0.0478	0.0430	9.8	10.2	3.5	3.3	2.4	2.3	0.0474	0.0426	9.0	8.8	3.3	3.4	2.3	2.3
3	.0509	.0517	10.1	10.2	3.7	3.7	2.3	2.5	.0565	.0517	9.6	9.2	3.7	3.6	2.5	2.5
4	.0557	.0550	11.0	10.5	3.7	3.6	2.4	2.4	.0588	.0553	9.7	9.2	3.7	3.8	2.5	2.5
5	.0574	.0559	10.8	10.6	3.7	3.6	2.4	2.5	.0600	.0589	9.8	9.5	3.7	3.7	2.5	2.6
6	.0579	.0541	10.7	11.0	3.7	3.6	2.5	2.5	.0620	.0560	9.8	9.2	3.8	3.7	2.6	2.7
7	.0551	.0535	10.2	10.7	3.6	3.6	2.5	2.4	.0600	.0577	10.0	9.1	3.7	3.8	2.6	2.7
8	.0498	.0500	10.0	10.1	3.4	3.5	2.5	2.3	.0627	.0534	9.9	8.8	3.8	3.5	2.7	2.8
9	.0520	.0499	10.0	10.3	3.4	3.5	2.5	2.5	.0600	.0521	9.8	8.6	3.7	3.7	2.7	2.7
10	.0487	.0485	10.0	10.3	3.4	3.4	2.5	2.4	.0531	.0500	9.0	8.6	3.7	3.5	2.5	2.6
11	....	.0495	....	9.5	....	3.8	....	2.5	.0579	.0455	9.4	8.3	3.7	3.4	2.6	2.5
12	....	.0399	....	9.6	....	3.4	....	2.3	.0543	....	9.1	....	3.4	....	2.6	....
13	....	....	....	....	....	....	....	....	.0478	....	8.5	....	3.5	....	2.5	....

JULY 31

Kernel No.	6 a. m. Weight A.	Weight B.	Length A.	Length B.	Lateral A.	Lateral B.	Dorso-ventral A.	Dorso-ventral B.	6.30 p. m. Weight A.	Weight B.	Length A.	Length B.	Lateral A.	Lateral B.	Dorso-ventral A.	Dorso-ventral B.
1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
2	0.0409	0.0443	7.9	8.9	3.3	3.4	2.4	2.4	0.0463	0.0374	7.5	8.0	3.5	3.3	2.4	2.3
3	.0511	.0503	9.2	9.1	3.8	3.5	2.5	2.4	.0545	.0493	8.1	9.0	3.7	3.5	2.6	2.5
4	.0559	.0579	9.0	9.8	3.8	3.7	2.6	2.5	.0615	.0554	9.5	8.3	3.7	3.7	2.8	2.7
5	.0565	.0575	9.0	9.7	3.7	3.7	2.5	2.5	.0600	.0565	9.2	9.0	3.7	3.7	2.7	2.7
6	.0561	.0582	9.1	9.7	3.7	3.7	2.6	2.5	.0588	.0552	9.2	9.0	3.7	3.6	2.7	2.6
7	.0552	.0550	9.0	9.7	3.8	3.5	2.6	2.5	.0593	.0552	9.5	9.1	3.7	3.7	2.7	2.5
8	.0525	.0575	8.7	9.6	3.7	3.5	2.6	2.6	.0574	.0553	9.3	8.9	3.7	3.7	2.7	2.5
9	.0521	.0581	8.9	9.3	3.5	3.5	2.6	2.6	.0537	.0515	8.7	8.5	3.6	3.4	2.5	2.5
10	.0487	.0557	8.7	9.1	3.5	3.5	2.6	2.6	.0533	.0512	8.5	8.7	3.5	3.6	2.6	2.6
11	.0488	.0552	8.4	9.2	3.5	2.5	2.5	2.6	.0510	.0450	8.7	8.2	3.7	3.5	2.6	2.4
12	.0388	.0534	7.9	9.1	3.2	3.5	2.3	2.6	....	.0370	....	7.6	....	3.0	....	2.4
13	....	.0469	....	8.8	....	3.3	....	2.5	....	....	....	....	....	....	....	....
14	....	.0361	....	8.0	....	3.0	....	2.3	....	....	....	....	....	....	....	....

AUGUST 1

Kernel No.	6 a. m. Weight A.	Weight B.	Length A.	Length B.	Lateral A.	Lateral B.	Dorso-ventral A.	Dorso-ventral B.	p. m. Weight A.	Weight B.	Length A.	Length B.	Lateral A.	Lateral B.	Dorso-ventral A.	Dorso-ventral B.
1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
2	0.0351	0.0451	8.4	8.8	3.2	3.5	2.0	2.3	....	0.0321	....	8.0	....	3.0	....	1.9
3	.0515	.0554	9.2	9.5	3.6	3.7	2.4	2.3	0.0500	.0525	9.1	9.0	3.3	3.7	2.3	2.3
4	.0577	.0625	9.8	9.6	3.5	3.7	2.5	2.6	.0566	.0597	9.0	9.6	3.6	3.6	2.6	2.7
5	.0614	.0611	9.5	9.4	3.7	3.8	2.6	2.6	.0575	.0604	9.2	9.3	3.8	3.8	2.6	2.7
6	.0588	.0599	9.5	9.8	3.8	3.8	2.5	2.6	.0598	.0589	9.3	9.6	3.9	3.8	2.6	2.7
7	.0583	.0615	9.2	9.3	3.7	3.9	2.6	2.6	.0598	.0589	9.4	9.0	3.7	3.8	2.5	2.6
8	.0581	.0594	9.4	9.4	3.6	3.7	2.6	2.5	.0578	.0596	9.0	9.1	3.7	3.8	2.6	2.7
9	.0589	.0589	9.3	9.4	3.8	3.7	2.6	2.6	.0571	.0589	9.3	9.3	3.7	3.8	2.7	2.5
10	.0563	.0557	9.4	9.2	3.7	2.7	2.6	2.6	.0571	.0558	9.0	9.0	3.7	3.6	2.7	2.5
11	.0550	.0521	9.1	8.7	3.6	3.6	2.6	2.4	.0536	.0556	9.0	9.0	3.7	3.7	2.6	2.5
12	.0527	.0473	9.0	8.4	3.5	3.4	2.5	2.5	.0500	.0505	8.6	8.6	3.3	3.5	2.6	2.4
13	.0514	....	8.6	....	3.5	....	2.5	....	.0454	.0443	8.3	8.4	3.4	3.2	2.4	2.4
14	.0450	....	8.4	....	3.3	....	2.4	....	....	....	....	....	....	....	....	....

TABLE I.—*Normal growth of Hannchen barley in 12-hour periods from flowering to maturity, at Aberdeen, Idaho, in 1917*—Continued

Kernel No. from base of spike.	Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorso-ventral diameter of kernel on spike—		Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorso-ventral diameter of kernel on spike—	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
	Gm.	Gm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Gm.	Gm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.
AUGUST 2																
	6 a. m.								7 p. m.							
1	....	....	.....	.....	.....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....
2	0.0302	....	7.7	.....	2.8	.....	2.0	.....	....	0.0404	.....	8.1	.....	3.3	.....	2.3
3	.0500	0.0528	8.9	9.1	3.6	3.4	2.4	2.4	0.0426	.0483	8.3	8.7	3.3	3.6	2.5	2.3
4	.0617	.0596	9.6	9.4	3.8	3.8	2.5	2.6	.0546	.0543	8.8	9.0	3.6	3.7	2.7	2.5
5	.0611	.0620	9.6	9.5	3.8	3.8	2.6	2.7	.0553	.0571	9.4	9.1	3.9	3.8	2.6	2.6
6	.0620	.0644	9.8	9.6	3.8	3.8	2.6	2.7	.0566	.0566	9.1	9.1	3.7	3.6	2.5	2.6
7	.0579	.0600	9.4	9.3	3.7	3.8	2.5	2.6	.0546	.0586	9.0	9.0	3.7	3.8	2.5	2.7
8	.0601	.0610	8.8	9.4	3.7	3.6	2.5	2.6	.0558	.0561	9.0	9.1	3.6	3.7	2.6	2.8
9	.0577	.0592	9.1	9.2	3.7	3.7	2.6	2.7	.0547	.0548	9.1	8.7	3.6	3.5	2.5	2.7
10	.0595	.0572	9.0	9.0	3.8	3.8	2.8	2.7	.0508	.0500	8.7	8.6	3.5	3.5	2.5	2.5
11	.0574	.0515	9.2	8.8	3.5	3.5	2.5	2.5	.0465	.0464	8.1	8.3	3.5	3.5	2.5	2.5
12	.0476	.0521	8.7	8.7	3.5	3.5	2.5	2.7	.0371	.0387	7.8	7.5	3.2	3.2	2.4	2.2
13	.0489	.0429	8.5	8.0	3.5	3.3	2.5	2.4	....	....	.....	.....	.....	.....	.....	.....
AUGUST 3																
	6 a. m.								6.45 p. m.							
1	....	....	.....	.....	.....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....
2	0.0363	....	8.0	.....	3.3	.....	2.2	.....	0.0521	0.0425	9.2	7.9	3.3	3.3	2.5	2.5
3	.0510	0.0510	9.2	8.8	3.6	3.5	2.3	2.5	.0639	.0548	9.1	9.8	3.8	3.7	2.7	2.7
4	.0560	.0572	9.5	9.0	3.5	3.8	2.4	2.6	.0644	.0565	9.4	9.0	4.0	3.6	2.7	2.6
5	.0573	.0595	9.2	9.6	3.6	3.8	2.6	2.6	.0650	.0558	9.6	8.8	3.7	3.6	2.6	2.5
6	.0621	.0608	9.2	9.2	3.7	3.8	2.7	2.7	.0651	.0551	9.4	9.0	3.8	3.6	2.5	2.5
7	.0580	.0602	9.0	9.3	3.6	3.8	2.6	2.5	.0633	.0554	9.3	8.7	3.8	3.7	2.8	2.6
8	.0573	.0579	9.1	9.2	3.6	3.5	2.5	2.5	.0651	.0540	9.3	8.5	3.9	3.6	2.8	2.7
9	.0602	.0583	8.8	9.0	3.6	3.5	2.5	2.6	.0629	.0513	9.2	8.0	3.8	3.5	2.6	2.8
10	.0600	.0577	8.7	8.9	3.7	3.8	2.7	2.6	.0599	.0476	9.1	7.8	3.7	3.3	2.7	2.5
11	.0531	.0545	8.7	8.7	3.5	3.7	2.6	2.6	.0591	.0437	8.8	7.6	3.7	3.4	2.7	2.5
12	.0531	.0504	8.7	8.4	3.6	3.7	2.6	2.6	.0536	....	8.4	.....	3.5	.....	2.7	.....
13	.0532	.0507	8.5	8.8	3.6	3.2	2.7	2.3	....	....	.....	.....	.....	.....	.....	.....
14	.0452	....	8.2	.....	3.2	.....	2.6	.....	....	....	.....	.....	.....	.....	.....	.....
AUGUST 4																
	5.45 a. m.								6.45 p. m.							
1	....	....	.....	.....	.....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....
2	0.0454	0.0409	8.0	8.3	3.4	3.4	2.4	2.3	0.0300	0.0386	7.8	8.2	2.8	3.1	2.0	2.1
3	.0537	.0550	8.7	8.9	3.6	3.7	2.4	2.6	.0567	.0623	9.0	9.3	3.7	3.7	2.6	2.7
4	.0594	.0600	9.1	9.3	3.7	3.8	2.7	2.5	.0656	.0668	9.3	9.7	3.9	3.8	2.7	2.6
5	.0605	.0596	9.3	9.6	3.7	3.7	2.8	2.6	.0629	.0675	9.6	9.8	3.7	3.7	2.8	2.7
6	.0577	.0626	9.2	9.6	3.6	3.7	2.6	2.7	.0629	.0645	9.3	9.6	3.8	3.7	2.8	2.7
7	.0580	.0617	9.1	9.6	3.5	3.8	2.6	2.9	.0660	.0655	9.2	9.4	3.7	3.7	2.9	2.7
8	.0539	.0592	9.0	9.0	3.4	3.8	2.5	2.6	.0614	.0660	9.4	9.4	3.7	3.8	2.8	2.8
9	.0556	.0557	8.8	9.1	3.7	3.5	2.7	2.7	.0614	.0633	9.1	9.1	3.7	3.7	2.8	2.7
10	.0539	.0565	9.0	9.0	3.7	3.5	2.8	2.8	.0546	.0617	9.0	9.1	3.5	3.8	2.7	2.7
11	.0475	.0550	8.2	9.0	3.5	3.5	2.6	2.7	.0546	.0596	8.9	9.0	3.7	3.7	2.5	2.8
12	.0400	.0480	7.8	8.3	3.2	3.4	2.4	2.6	.0532	.0582	8.5	9.0	3.5	3.7	2.6	2.7
13	....	....	.....	.....	.....	.....	.....	.....	.0448	.0548	7.9	8.5	3.3	3.5	2.6	2.8
14	....	....	.....	.....	.....	.....	.....	.....	....	.0483	.....	8.3	.....	3.4	.....	2.6

TABLE I.—*Normal growth of Hannchen barley in 12-hour periods from flowering to maturity, at Aberdeen, Idaho, in 1917*—Continued

AUGUST 5

Kernel No. from base of spike.	6 a. m. Weight of kernel on spike— A.	6 a. m. Weight of kernel on spike— B.	6 a. m. Length of kernel on spike— A.	6 a. m. Length of kernel on spike— B.	6 a. m. Lateral diameter of kernel on spike— A.	6 a. m. Lateral diameter of kernel on spike— B.	6 a. m. Dorso-ventral diameter of kernel on spike— A.	6 a. m. Dorso-ventral diameter of kernel on spike— B.	6.30 p. m. Weight of kernel on spike— A.	6.30 p. m. Weight of kernel on spike— B.	6.30 p. m. Length of kernel on spike— A.	6.30 p. m. Length of kernel on spike— B.	6.30 p. m. Lateral diameter of kernel on spike— A.	6.30 p. m. Lateral diameter of kernel on spike— B.	6.30 p. m. Dorso-ventral diameter of kernel on spike— A.	6.30 p. m. Dorso-ventral diameter of kernel on spike— B.
	Gm.	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
2	0.0252	0.0461	7.2	8.1	2.6	3.4	1.9	2.4	0.0300	....	7.0	....	3.0	....	2.0	....
3	.0590	.0543	9.1	8.8	3.8	3.6	2.7	2.5	.0538	0.0528	8.9	8.4	3.5	3.5	2.3	2.5
4	.0631	.0601	8.9	8.8	3.8	3.7	2.8	2.8	.0597	.0592	8.7	9.2	3.6	3.7	2.5	2.6
5	.0637	.0559	9.3	9.2	3.8	3.5	2.7	2.7	.0635	.0596	9.3	9.0	3.9	3.5	2.6	2.7
6	.0671	.0585	9.4	8.9	3.8	3.7	2.8	2.7	.0600	.0614	8.7	9.1	3.8	3.7	2.6	2.8
7	.0627	.0562	8.7	8.7	3.9	3.7	2.7	2.6	.0639	.0614	8.8	9.0	3.7	3.7	2.8	2.7
8	.0609	.0535	9.1	8.7	3.7	3.5	2.8	2.6	.0598	.0588	8.6	8.9	3.7	3.7	2.7	2.7
9	.0593	.0527	9.0	8.5	3.7	3.6	2.7	2.6	.0587	.0551	8.8	8.2	3.8	3.4	2.6	2.6
10	.0564	.0503	8.5	8.4	3.6	3.5	2.7	2.6	.0574	.0542	8.7	8.5	3.7	3.5	2.7	2.7
11	.0507	.0446	8.3	7.7	3.4	3.4	2.7	2.6	.0539	.0466	8.5	8.0	3.4	3.4	2.6	2.5
12	....	....	....	....	....	....	....	....	.0515	.0441	8.3	7.6	3.4	3.4	2.5	2.4
13	....	....	....	....	....	....	....	....	.0456	....	8.1	....	3.3	....	2.5	....

AUGUST 6

Kernel No. from base of spike.	6 a. m. Weight A.	6 a. m. Weight B.	6 a. m. Length A.	6 a. m. Length B.	6 a. m. Lateral A.	6 a. m. Lateral B.	6 a. m. Dorso-ventral A.	6 a. m. Dorso-ventral B.	6.40 p. m. Weight A.	6.40 p. m. Weight B.	6.40 p. m. Length A.	6.40 p. m. Length B.	6.40 p. m. Lateral A.	6.40 p. m. Lateral B.	6.40 p. m. Dorso-ventral A.	6.40 p. m. Dorso-ventral B.
1	....	....	....	....	....	....	....	....	0.0231	....	7.2	....	2.6	....	1.8	....
2	0.0528	0.0560	8.9	8.9	3.7	3.7	2.5	2.6	.0534	0.0513	8.7	8.7	3.5	3.5	2.5	2.5
3	.0639	.0606	9.4	8.9	3.8	3.8	2.7	2.8	.0617	.0578	9.2	8.9	3.6	3.6	2.5	2.8
4	.0634	.0615	9.4	9.0	3.8	3.7	2.8	2.7	.0648	.0580	9.2	8.8	3.7	3.5	2.7	2.8
5	.0657	.0622	9.6	9.4	3.8	3.8	2.8	2.8	.0624	.0566	9.3	8.9	3.6	3.5	2.7	2.7
6	.0675	.0634	9.7	9.1	3.9	3.8	2.9	2.7	.0624	.0553	9.1	8.6	3.5	3.5	2.7	2.7
7	.0628	.0602	9.1	8.9	3.8	3.6	2.7	2.7	.0613	.0561	8.7	8.8	3.7	3.5	2.7	2.7
8	.0626	.0566	9.4	8.9	3.8	3.6	2.9	2.6	.0589	.0512	9.0	8.3	3.5	3.4	2.7	2.6
9	.0623	.0550	9.0	8.4	3.7	3.5	2.9	2.6	.0576	.0476	8.8	8.1	3.5	3.3	2.7	2.6
10	.0580	.0528	8.6	8.2	3.6	3.5	2.8	2.6	.0509	.0479	8.5	8.1	3.4	3.3	2.7	2.6
11	.0576	.0513	8.7	8.2	3.6	3.5	2.6	2.7	.0491	.0330	8.3	7.6	3.4	2.9	2.6	2.3
12	.0534	.0487	8.5	8.2	3.5	3.5	2.7	2.6	.0444	....	8.1	....	3.2	....	2.4	....

AUGUST 7

Kernel No. from base of spike.	6 a. m. Weight A.	6 a. m. Weight B.	6 a. m. Length A.	6 a. m. Length B.	6 a. m. Lateral A.	6 a. m. Lateral B.	6 a. m. Dorso-ventral A.	6 a. m. Dorso-ventral B.	7 p. m. Weight A.	7 p. m. Weight B.	7 p. m. Length A.	7 p. m. Length B.	7 p. m. Lateral A.	7 p. m. Lateral B.	7 p. m. Dorso-ventral A.	7 p. m. Dorso-ventral B.
1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
2	0.0571	0.0568	8.6	8.3	3.7	3.6	2.5	2.6	0.0541	0.0523	8.7	8.5	3.7	3.5	2.6	2.5
3	.0616	.0641	9.5	9.0	3.7	3.9	2.5	2.8	.0567	.0592	9.0	8.9	3.6	3.8	2.8	2.8
4	.0657	.0646	9.4	9.1	3.7	3.8	2.6	2.8	.0579	.0619	9.0	9.0	3.7	3.8	2.7	2.8
5	.0690	.0623	9.6	9.4	3.8	3.6	3.0	2.6	.0561	.0626	8.5	8.9	3.5	3.7	2.6	2.7
6	.0672	.0623	9.4	9.3	3.6	3.7	2.9	2.7	.0605	.0618	9.3	9.0	3.7	3.7	2.8	2.7
7	.0674	.0623	9.2	8.8	3.7	3.7	2.8	2.8	.0589	.0610	8.9	8.9	3.7	3.7	2.7	2.8
8	.0639	.0627	9.0	8.7	3.7	3.6	2.8	2.9	.0575	.0600	8.7	9.0	3.5	3.7	2.6	2.8
9	.0592	.0585	9.1	8.8	3.5	3.7	2.6	2.6	.0558	.0597	8.7	8.5	3.5	3.7	2.8	2.7
10	.0626	.0570	8.7	8.5	3.8	3.6	2.7	2.8	.0559	.0573	8.5	8.5	3.5	3.5	2.8	2.6
11	.0591	.0533	8.5	8.5	3.7	3.6	2.6	2.7	.0480	.0516	8.0	8.5	3.4	3.2	2.6	2.6
12	.0576	.0465	8.4	8.3	3.5	3.4	2.7	2.5	.0432	.0488	8.2	8.0	3.2	3.4	2.5	2.5
13	.0480	....	8.2	....	3.4	....	2.6	....	....	.0399	....	8.0	....	3.1	....	2.3

TABLE I.—*Normal growth of Hannchen barley in 12-hour periods from flowering to maturity, at Aberdeen, Idaho, in 1917*—Continued

AUGUST 8

Kernel No. from base of spike.	6 a. m.								6.40 p. m.							
	Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorsoventral diameter of kernel on spike.		Weight of kernel on spike—		Length of kernel on spike—		Lateral diameter of kernel on spike—		Dorsoventral diameter of kernel on spike—	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
	Gm.	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
1	0.0363	0.0243	7.7	6.7	3.0	2.7	2.1	1.9	....	....	.....	.....	.....	.....	.....	.....
2	.0595	.0532	8.6	8.0	3.6	3.6	2.7	2.5	....	0.0440	.....	7.8	.....	3.2	.....	2.5
3	.0613	.0618	8.8	8.7	3.6	3.8	2.6	2.8	0.0502	.0571	8.4	8.4	3.5	3.5	2.7	2.6
4	.0655	.0634	9.3	8.9	3.8	3.7	2.9	2.7	.0578	.0609	8.6	9.0	3.6	3.6	2.7	2.7
5	.0682	.0647	9.2	9.2	3.6	3.8	2.7	2.8	.0590	.0570	9.0	8.8	3.6	3.6	2.7	2.6
6	.0659	.0624	9.0	8.7	3.7	3.7	2.7	2.8	.0569	.0576	8.8	8.8	3.5	3.5	2.6	2.6
7	.0659	.0626	9.0	8.8	3.6	3.6	2.8	2.8	.0581	.0554	8.8	8.9	3.6	3.5	2.7	2.6
8	.0634	.0615	8.9	8.6	3.6	3.7	2.7	2.8	.0565	.0553	8.6	8.5	3.5	3.5	2.6	2.7
9	.0642	.0604	8.6	8.4	3.7	3.7	2.8	2.7	.0508	.0539	8.6	8.6	3.4	3.4	2.5	2.6
10	.0607	.0590	8.2	8.4	3.6	3.7	2.8	2.8	.0511	.0507	8.4	8.4	3.5	3.5	2.6	2.7
11	.0585	.0500	8.6	8.0	3.5	3.5	2.7	2.4	.0423	.0412	7.8	7.6	3.2	3.1	2.4	2.5
12	.0546	.0453	8.1	7.7	3.4	3.3	2.7	2.4	....	....	.....	.....	.....	.....	.....	.....
13	.0420	....	7.7	.....	3.1	.....	2.5	.....	....	....	.....	.....	.....	.....	.....	.....

The course of growth is more apparent in Table II, where the results have been summarized in 24-hour periods. That is, the weights and measurements of all the kernels on each spike of the two samples have been averaged and these averages placed opposite the dates. No summary was made for the data in 12-hour periods, because the daily changes of dimension after the first few days were too slight to be shown in so short a period. Growth in length in the early stages, however, is perfectly apparent in 12 hours.

TABLE II.—*Average wet weight, length, lateral diameter, and dorsoventral diameter of kernels of Hannchen barley in 24-hour periods from flowering to maturity at Aberdeen, Idaho, in 1917*

Date.	Wet weight.	Length.	Lateral diameter.	Dorsoventral diameter.	Date.	Wet weight.	Length.	Lateral diameter.	Dorsoventral diameter.
	Mgm.	*Mm.*	*Mm.*	*Mm.*		*Mgm.*	*Mm.*	*Mm.*	*Mm.*
July 15	1.9	2.27	1.26	....	July 28	48.2	10.02	3.47	2.33
16	3.0	2.88	1.32	0.74	29	49.0	9.84	3.50	2.42
17	4.5	3.93	1.39	.82	30	53.0	9.99	3.59	2.50
18	8.0	6.05	1.57	.90	31	52.2	8.83	3.56	2.54
19	12.7	7.91	1.79	1.16	Aug. 1	54.8	9.10	3.62	2.51
20	15.8	8.78	1.94	1.30	2	53.3	8.87	3.59	2.54
21	19.2	9.32	2.10	1.48	3	55.8	8.87	3.61	2.59
22	25.7	9.81	2.51	1.71	4	56.3	8.96	3.60	2.64
23	31.0	9.96	2.80	1.90	5	55.9	8.66	3.60	2.62
24	32.7	9.83	2.86	1.90	6	56.6	8.78	3.57	2.67
25	36.0	9.80	3.02	2.05	7	58.0	8.77	3.60	2.68
26	38.2	9.77	3.09	2.06	8	56.1	8.53	3.53	2.64
27	44.6	9.98	3.30	2.25					

The significance of the data in Table II is, perhaps, more easily seen in figure 1. The most surprising feature shown by this figure is the remarkably rapid growth in length following fertilization. In the two days from the second to the fourth after fertilization, half the growth in length occurs. The insufficiency of 3-day intervals in sampling at this stage is obvious. Distinct growth is shown in 12-hour periods, and it is probable that consistent increase would be revealed in 6-hour periods. The kernel reached its maximum length by the end of 7 days in each year. After the peak of length is reached, there is a gradual decrease to maturity. This is discussed later in connection with figure 4.

The lateral diameter exhibits its most rapid increase as soon as the rate of the growth in length diminishes. This increase continues until about the fifteenth day, after which the lateral diameter remains more or less stationary. The dorsoventral diameter, on the other hand, continues to increase almost until maturity. The increase is somewhat less than in the lateral diameter, there being a greater divergence in the growth curves at the end of the growing period than at the beginning. The effect of the better irrigation in 1916 is apparent throughout the period of growth. There is a possibility that the 1916 samples are a few hours farther advanced throughout the series because of differences in temperature or other factors at flowering time. While growth itself is not so easily affected, fertilization is often hastened or delayed many hours by conditions in the environment.

During the early growth of the kernel the ovary tip undergoes a sympathetic development. When the kernel is first developing, the growth is largely in the pericarp. Some of the tissues surrounding the embryo sac and the ovary walls of the same region develop rapidly and are to be found in the ripened caryopsis. For some reason, the tissues above the embryo sac are temporarily stimulated, forming a body at the end of the kernel, which is referred to here as the ovary tip. This growth, which may be seen in Plates 83 and 84, is of importance because it introduces an error in the measurement of length. After the growth of the first few days, this organ remains stationary in size for a while and finally is largely resorbed. In figure 1 it will be seen that it was possible to measure the kernel proper without this tip by the fifteenth day after flowering. The records of lengths until that time included the ovary tip. The lateral and dorsoventral diameters of the ovary tip are shown in figure 4. It is probable that the length of the kernel proper increased somewhat after it had apparently reached its maximum by invading the tissues of the ovary tip. This tissue is probably partially responsible for the difference of measurements in the first 15 days of the two years. A second factor in the error lies in the softness of the structure at the base of the kernel. In the early stages of growth it is exceedingly difficult to place the caliper bar at exactly the right point, and in 1917 the kernels may have been measured more closely than in 1916. The difference of the

two years, however, is less than 0.5 mm., so that the data coincide far beyond any reasonable expectation.

The reason that errors in this connection are suggested is that it is not plausible that the differences in soil or water would affect the kernels by

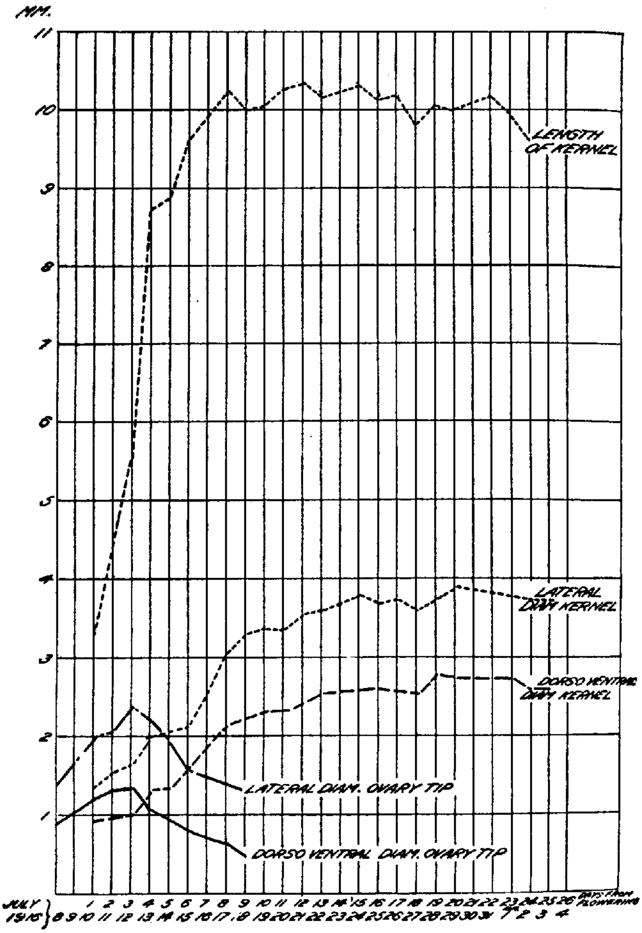


FIG. 4.—Graph showing lateral and dorsoventral diameters of the ovary tip as compared with length, lateral diameter, and dorseventral diameter of the kernel for the 26 days following flowering in 1916.

this time, since there obviously is no insufficiency of nutrients for this primary growth. These data have an incidental bearing on the value of observations on the length and diameter of kernels. Such observations are used frequently to identify varieties. In 1914, the author (2) stated

that length was more dependable than lateral diameter and that lateral diameter was more dependable than dorsoventral diameter in the description of types. The same observations have been made, presumably, by many others. The growth curves confirm this opinion. The length is quickly attained and should vary little with season. The lateral diameter reaches its maximum more slowly than the length, but much sooner than the dorsoventral diameter, which is dependent upon conditions throughout the growing season for the fulfillment of its maximum possibilities.

As has been inferred before, the kernels at the base and the tip of the spike are more variable than those near the center. With the increase of the number of kernels on the spike those at the extremes are likely to suffer from competition. On any spike, if nutrition at any time becomes insufficient, the basal and the apical kernels are the first to be affected. Averages which include these kernels show greater fluctuations than those from which they are excluded. This variation was overcome partially by including in the averages no basal kernels which weighed less than half as much as the kernel next above. Since this does not entirely overcome the difficulty the average length, lateral diameter, and dorsoventral diameter of kernels 6, 7, and 8 are plotted in figure 5 as an illustration of the behavior of more typical kernels. It will be seen that the daily fluctuations are much reduced.

EFFECT OF POSITION OF KERNEL ON GROWTH

There are two main factors that affect the relative size of kernels. These are age and the position of the kernel on the spike. The relative importance of these factors varies with the stage of growth. The age of the kernel depends on the time of flowering. The florets of a spike are not all fertilized on the same day. The earliest flowers usually are those located about two-thirds the distance from the base of the spike to the tip. The last to fertilize are the extreme basal and apical florets. The largest florets are found one-third the length of the spike from the base. Presumably, the kernels found in these florets receive more nourishment than those at the tip, especially toward the end of the growing period. The length of each kernel on one side of the spike is shown by days in figure 6. The growth is practically completed in these eight days. As will be seen, florets 8, 9, and 10 are the first to fertilize and to begin growth. By the third day these three kernels have reached their greatest relative advancement. After the second day there is a gradual shift in the peak of the curve as the basal kernels approach the others in total length. By the fourth day kernels 8, 9, and 10 are no longer prominent, and on the fifth day the curve is extremely regular. By the eighth day the length growth is complete and the longest kernels are the fifth and sixth. The curve of the eighth is thought to be more typical than that of the seventh.

The data for the lateral diameter are shown in the same way in figure 7. The same progress of size from the eighth, ninth, and tenth kernels toward the base is to be seen as was found in the length. Here also, the fifth and sixth kernels have exceeded the upper ones by the eighth day

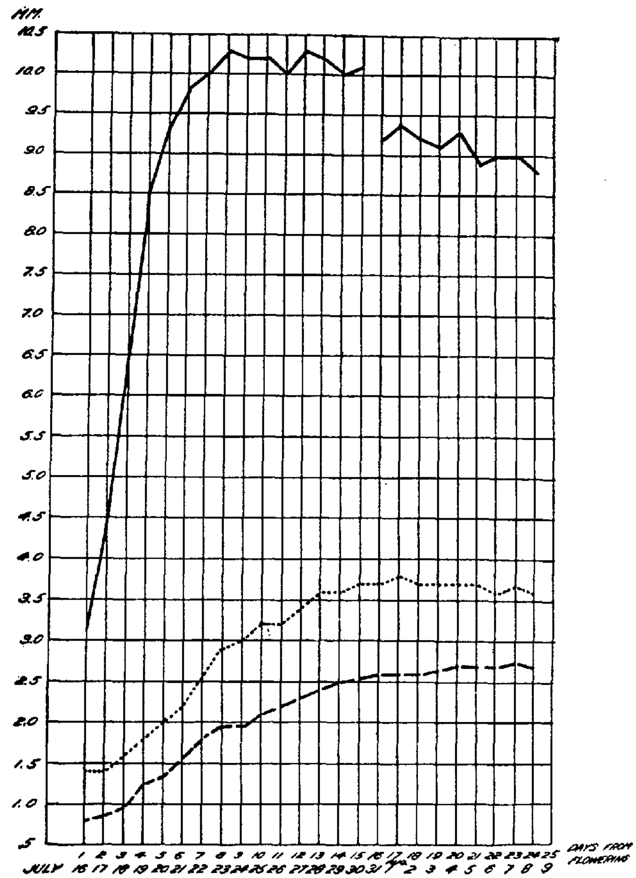


FIG. 5.—Graph showing average length of kernels 6, 7, and 8 (solid line), average lateral diameter (dotted line), and average dorsoventral diameter (broken line) from plot 1 in 1917.

after flowering. The growth in lateral diameter has been practically completed by the sixteenth day. The measurements after the tenth day are given only on alternate days, because the daily increase is so small that the inclusion of all days causes the lines to become confused.

The dorsoventral diameter continues to increase for a longer period. As may be seen in figure 8, the full growth is attained on the twenty-third day after flowering. The greatest diameters in the early growth

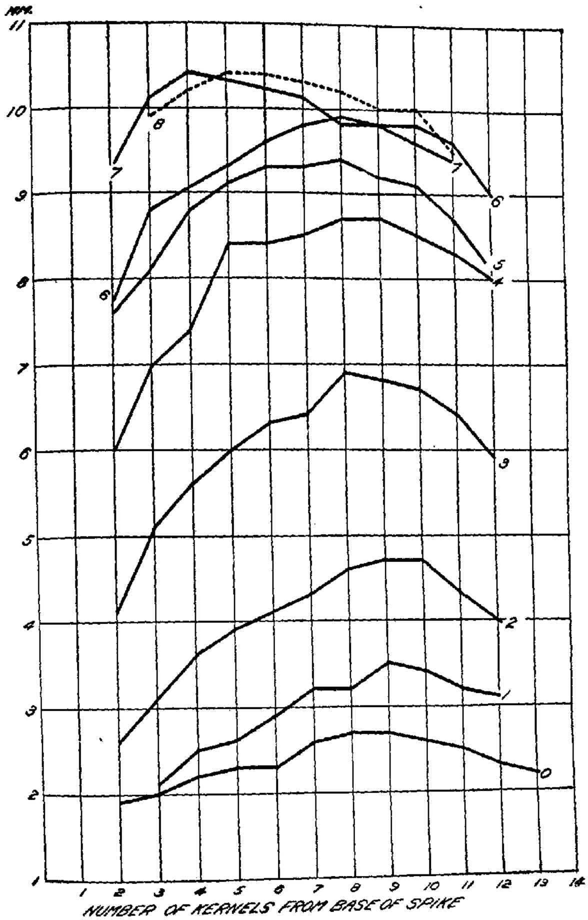


FIG. 6.—Graph showing average length of barley kernels, including ovary tip, from flowering to near maximum development in plot 1 in 1917. Numerals at ends of lines indicate days from flowering.

are to be found in kernels 8, 9, and 10, as was the case in the length and in the lateral diameter. On the fourth, fifth, and sixth days after flowering these kernels are conspicuously in advance of the rest of the spike.

Again, as in the length and the lateral diameter, the kernels toward the base increase more rapidly. The fourth kernel never becomes as prominent as it does in the other measurements. After the growth in length and lateral diameter has been completed, there is a tendency toward a greater permanent increase in the kernels near the center of the spike.

As a whole, the progress of kernel growth is significantly indicated by these three measurements. After the peak is reached there is a slight decrease as maturity approaches. This is especially true in the length

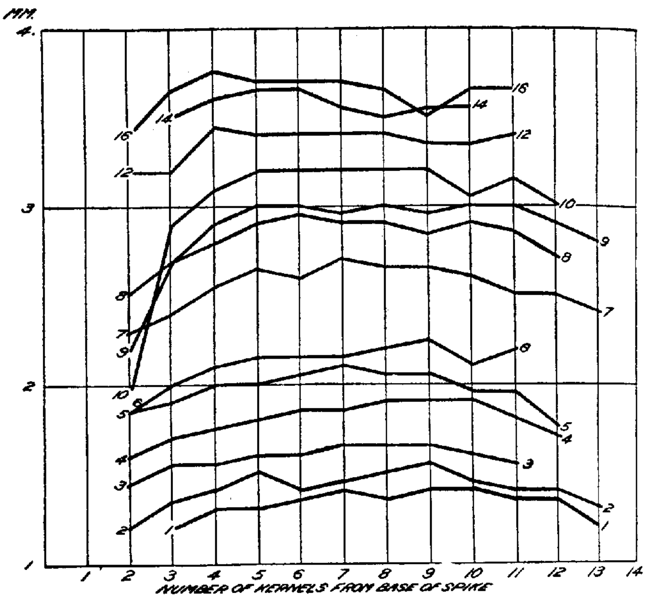


FIG. 7.—Graph showing average lateral diameter of barley kernels from flowering until near maximum development, plot 1, 1917. Numerals at end of lines indicate days from flowering.

and in the lateral diameter. This fact will be referred to again when the course of water content is discussed.

COURSE BY DAYS OF DRY MATTER, WATER, NITROGEN, AND ASH IN THE KERNEL FROM FLOWERING TO MATURITY

The chemical phase of the study is based on the laboratory determinations made on the same samples from which the measurements were secured. In 1916 the material was analyzed by Mr. Anthony. The analyses in 1917 were made by the Bureau of Chemistry of the United States Department of Agriculture. While the chemical investigations involved no such elaborate determinations as those of Schjerning, the results are parallel with those from his work and that of Wheldale.

Table III is a summary of the results obtained and computed on each spike of each sample for 1917. In each sample the material from one spike was used for nitrogen determinations and the material from the

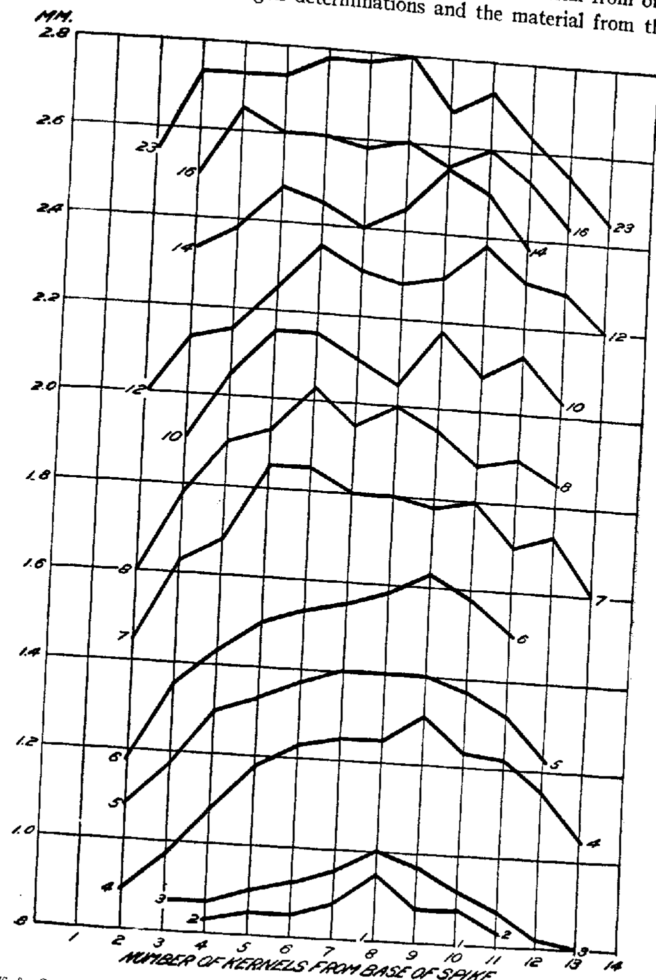


FIG. 8.—Graph showing dorsoventral diameters of barley kernels from flowering until near maximum development. Numerals at ends of lines indicate days from flowering.

other for ash determinations. In the early growth a third spike was sometimes added, but these third spikes are not in the summary, since they were not reported in Table I. Because of the limited amount of

material, the analyses are not always dependable. This is true especially for the first few days after flowering. As may be seen from the table, the weight of the individual kernels was greater at maturity than the weight of all the kernels of a spike at flowering time. In some cases where the analyses were obviously incorrect, the results are omitted. But, despite the small samples, the trend of the analyses is surprisingly uniform and, as the results of the two years are in such close agreement, the results are significant. The nitrogen determination is naturally the least dependable. The results in the ash determinations are more accurate, and there is no reason why the dry matter content should not be absolutely so. The dry weight, nitrogen, and ash per kernel are computed by means of the percentages secured in the whole spike.

TABLE III.—*Summary of data on weight, dry matter, water, nitrogen, and ash in individual spikes of Hannchen barley in 12-hour periods at Aberdeen, Idaho, in 1917*

Time.	Spike.	Wet weight.	Dry weight.	Dry matter.	Water.	Nitrogen in dry matter.	Ash in dry matter.	Wet weight per kernel.	Dry weight per kernel.	Nitrogen per kernel.	Ash per kernel.
		Gm.	*Gm.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Mgm.*	*Mgm.*	*Mgm.*	*Mgm.*
July 15:											
7 p. m.	A	0.0441	0.0064	14.5	85.5	3.75	......	1.875	0.272	0.010	......
7 p. m.	B	.0494	.0085	17.2	82.8	......	......	1.862	.320	......	......
July 16:											
6 a. m.	A	.0578	.0093	16.1	83.9	4.19	......	2.275	.366	.015	......
6 a. m.	B	.0657	.0084	12.8	87.2	......	......	2.650	.339	......	......
7 p. m.	A	.0745	.0126	16.9	83.1	4.45	......	3.400	.575	.026	......
7 p. m.	B	.0778	.0139	17.9	82.1	......	7.91	3.550	.635	......	0.050
July 17:											
6 a. m.	A	.0807	.0149	18.5	81.5	3.00	......	3.050	.564	.017	......
6 a. m.	B	.0795	.0145	18.2	81.8	......	8.96	3.400	.619	......	.056
7 p. m.	A	.1360	.0270	19.9	80.1	3.11	......	5.909	1.176	.037	......
7 p. m.	B	.1395	.0273	19.6	80.4	......	5.86	5.592	1.096	......	.064
July 18:											
6 a. m.	A	.1767	.0341	19.3	80.7	......	......	8.500	1.641	......	......
6 a. m.	B	.1477	.0274	18.6	81.4	......	6.57	6.418	1.194	......	.078
6 a. m.	C	.1964	.0385	19.6	80.4	......	5.71	7.650	1.499	......	.086
7 p. m.	A	.1940	.0406	20.9	79.1	......	......	8.391	1.754	......	......
July 19:											
6 a. m.	A	.2652	.0540	20.4	79.6	......	......	10.883	2.220	......	......
6 a. m.	B	.2940	.0637	21.7	78.3	......	3.77	12.327	2.675	......	.101
6 a. m.	C	.2389	.0516	21.6	78.4	......	4.26	11.590	2.503	......	.107
7 p. m.	A	.2829	.0651	23.0	77.0	......	......	14.720	3.386	......	......
7 p. m.	C	.2744	.0619	22.6	77.4	......	4.20	13.027	2.944	......	.124
July 20:											
6 a. m.	A	.3216	.0723	22.5	77.5	......	......	14.672	3.301	......	......
6 a. m.	B	.3508	.0798	22.7	77.3	......	4.51	16.370	3.716	......	.168
6 a. m.	C	.3863	.0878	22.7	77.3	......	3.08	16.417	3.727	......	.115
7 p. m.	A	.3026	.0678	22.4	77.6	2.27	......	13.900	3.114	.071	......
7 p. m.	B	.3452	.0756	21.9	78.1	......	4.63	17.600	3.854	......	.178
July 21:											
6 a. m.	A	.3356	.0760	22.6	77.4	3.14	......	16.820	3.801	.119	......
6 a. m.	B	.3772	.0875	23.2	76.8	......	3.54	18.560	4.306	......	.152
7 p. m.	A	.4192	.1060	25.3	74.7	......	......	20.655	5.226	......	......
July 22:											
6 a. m.	A	.5163	.1328	25.7	74.3	2.33	......	25.460	6.543	.152	......
6 a. m.	B	.5996	.1558	26.0	74.0	......	3.21	26.142	6.797	......	.218
7 p. m.	A	.5445	.1395	25.6	74.4	2.33	......	25.555	6.542	.152	......
7 p. m.	B	.6373	.1635	25.7	74.3	......	3.79	25.492	6.551	......	.248
July 23:											
6 a. m.	A	.6429	.1800	28.0	72.0	2.18	......	32.160	9.005	.196	......
6 a. m.	B	.5810	.1602	27.6	72.4	......	4.18	29.630	8.178	......	.342
7 p. m.	A	.7469	.2194	29.4	70.6	1.95	......	33.345	9.803	.191	......
7 p. m.	B	.6699	.1944	29.0	71.0	3.09	3.09	28.891	8.378	......	.259
July 24:											
6 a. m.	A	.6979	.2150	30.8	69.2	2.08	......	31.200	9.610	.200	......
6 a. m.	B	.7856	.2277	29.0	71.0	......	3.07	31.483	9.130	......	.280
7 p. m.	A	.6967	.2197	31.5	68.5	2.17	......	33.720	10.622	.230	......
7 p. m.	B	.8496	.2741	32.3	67.7	......	2.77	34.592	11.173	......	.309
July 25:											
6 a. m.	A	.8208	.2718	33.1	66.9	1.96	......	37.055	12.265	.240	......
6 a. m.	B	.8024	.2496	31.1	68.9	......	2.88	35.482	11.035	......	.328
7 p. m.	A	.7131	.2618	36.7	63.3	1.92	......	34.527	12.671	.243	......
7 p. m.	B	.6832	.2285	33.4	66.6	......	2.93	37.100	12.391	......	.363

TABLE III.—*Summary of data on weight, dry matter, water, nitrogen, and ash in individual spikes of Hannchen barley in 12-hour periods at Aberdeen, Idaho, in 1917*—Continued

Time.	Spike.	Wet weight.	Dry weight.	Dry matter.	Water.	Nitrogen in dry matter.	Ash in dry matter.	Wet weight per kernel.	Dry weight per kernel.	Nitrogen per kernel.	Ash per kernel.
		Gm.	*Gm.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Mgm.*	*Mgm.*	*Mgm.*	*Mgm.*
July 26:											
6 a. m.	A	0.7677	0.2608	34.0	66.0	2.04	......	36.640	12.458	0.254	......
6 a. m.	B	.7302	.2630	36.0	64.0	......	2.62	36.660	13.198	......	0.346
7 p. m.	A	.7955	.3000	37.7	62.3	1.87	......	39.860	15.027	.281	......
7 p. m.	B	.8527	.3164	37.1	62.9	......	2.72	39.682	14.722	......	.400
July 27:											
6 a. m.	A	1.0141	.3712	36.6	63.4	2.04	......	43.200	15.811	.323	......
6 a. m.	B	.9320	.3405	36.5	63.5	......	2.61	45.364	16.558	......	.432
7 p. m.	A	1.1596	.4435	38.2	61.8	2.02	......	44.731	17.087	.345	......
7 p. m.	B	.8451	.3205	37.9	62.1	......	2.84	45.130	17.104	......	.486
July 28:											
6 a. m.	A	1.1301	.4025	35.6	64.4	2.09	......	45.550	16.216	.339	......
6 a. m.	B	1.2476	.4902	39.3	60.7	......	2.41	49.300	19.375	......	.467
7 p. m.	A	1.0862	.4515	41.6	58.4	1.86	......	48.991	20.380	.379	......
7 p. m.	B	1.1338	.4674	41.2	58.8	......	2.42	48.775	20.095	......	.486
July 29:											
6 a. m.	A	.9978	.4061	40.7	59.3	1.86	......	49.570	20.175	.375	......
6 a. m.	B	.9214	.3614	39.2	60.8	......	2.49	47.180	18.495	......	.461
7 p. m.	A	.9233	.3847	41.7	58.3	2.19	......	49.590	20.679	.453	......
7 p. m.	B	.9841	.4237	43.1	56.9	......	2.43	49.540	21.352	......	.519
July 30:											
6 a. m.	A	.9350	.4015	42.9	57.1	2.02	......	52.811	22.656	.458	......
6 a. m.	B	1.1415	.4725	41.4	58.6	......	2.10	50.091	20.738	......	.435
7 p. m.	A	1.3826	.6008	43.5	56.5	2.00	......	56.708	24.668	.493	......
7 p. m.	B	1.0599	.4701	44.4	55.6	......	2.28	52.320	23.230	......	.530
July 31:											
6 a. m.	A	1.1090	.4837	43.6	56.4	2.09	......	50.600	22.062	.461	......
6 a. m.	B	1.3637	.6065	44.5	55.5	......	2.41	52.777	23.486	......	.566
6.30 p. m.	A	1.1058	.5098	46.1	53.9	2.14	......	55.580	25.622	.548	......
6.30 p. m.	B	1.0597	.5038	47.5	52.5	......	2.22	49.909	23.707	......	.526
August 1:											
6 a. m.	A	1.3393	.6261	46.7	53.3	1.89	......	53.862	25.154	.475	......
6 a. m.	B	1.2231	.5814	47.5	52.5	......	2.27	56.264	26.725	......	.607
6.30 p. m.	A	1.2283	.5928	48.3	51.7	2.08	......	54.973	26.552	.552	......
6.30 p. m.	B	1.2051	.6012	49.9	50.1	......	2.25	53.933	26.913	......	.606
August 2:											
6 a. m.	A	1.2996	.6071	46.8	53.2	1.82	......	54.508	25.510	.464	......
6 a. m.	B	1.2460	.5969	47.9	52.1	......	1.94	56.609	27.116	......	.526
6.30 p. m.	A	.9942	.4974	50.0	50.0	1.97	......	50.860	25.430	.501	......
6.30 p. m.	B	.9693	.4818	49.7	50.3	......	2.12	51.027	25.300	......	.538
August 3:											
6 a. m.	A	1.3453	.6846	50.9	49.1	1.85	......	54.062	27.518	.509	......
6 a. m.	B	1.1579	.5711	49.3	50.7	......	2.10	56.200	27.707	......	.582
6.45 p. m.	A	1.3575	.6850	50.5	49.5	2.04	......	61.309	30.961	.632	......
6.45 p. m.	B	1.0280	.5161	50.2	49.8	......	2.00	51.670	25.938	......	.519
August 4:											
5.45 a. m.	A	1.0870	.5380	49.5	50.5	1.85	......	53.236	26.352	.488	......
5.45 a. m.	B	1.1618	.5690	49.0	51.0	......	1.97	55.836	27.360	......	.539
6.45 p. m.	A	1.3289	.6795	51.1	48.9	2.18	......	56.175	28.705	.626	......
6.45 p. m.	B	1.5152	.8077	53.3	46.7	......	1.97	59.777	31.861	......	.628
August 5:											
6 a. m.	A	1.1586	.5882	50.8	49.2	1.86	......	60.322	30.644	.570	......
6 a. m.	B	.9911	.5175	52.2	47.8	......	1.93	53.220	27.781	......	.536
6.30 p. m.	A	1.3447	.7412	55.1	44.9	1.91	......	54.817	30.204	.577	......
6.30 p. m.	B	1.1509	.6146	53.4	46.6	......	1.94	55.320	29.541	......	.573
August 6:											
6 a. m.	A	1.3166	.6978	53.0	47.0	2.03	......	60.909	32.282	.655	......
6 a. m.	B	1.2923	.6779	52.5	47.5	......	1.83	57.118	29.987	......	.549
6.40 p. m.	A	1.3166	.7470	56.7	43.3	1.97	......	56.991	32.314	.637	......
6.40 p. m.	B	1.0200	.5907	57.9	42.1	......	1.95	51.480	29.807	......	.581
August 7:											
6 a. m.	A	1.5329	.8254	53.8	46.2	2.27	......	61.608	33.145	.752	......
6 a. m.	B	1.2783	.7104	55.6	44.4	......	1.93	59.127	32.875	......	.634
7 p. m.	A	1.0927	.6367	58.3	41.7	......	......	54.964	32.044	......	......
7 p. m.	B	1.3414	.7723	57.6	42.4	......	1.93	56.342	32.453	......	.626
August 8:											
6 a. m.	A	1.4838	.8217	55.4	44.6	2.28	......	58.923	32.643	.744	......
6 a. m.	B	1.3004	.7457	57.3	42.7	......	1.98	58.573	33.562	......	.665
6.40 p. m.	A	1.0100	.5903	58.4	41.6	......	......	53.633	31.322	......	......
6.40 p. m.	B	1.0614	.6083	57.3	42.7	......	1.77	53.310	30.547	......	.541

The material in Table III is summarized in Table IV. In the first part of Table IV the spikes of each sample are combined so as to give the average growth in 12-hour periods. In the second part of the table the

morning and evening averages are united to give the average growth in 24-hour periods. While many points of interest are perfectly apparent in the table, it is more convenient to discuss these data under the headings of the separate constituents, where the results are represented graphically.

TABLE IV.—*Average percentage of dry matter and water per kernel in Hannchen barley, percentage of nitrogen and ash in dry matter, and actual total weight, weight of dry matter, water, nitrogen, and ash at 12-hour and 24-hour periods at Aberdeen, Idaho, in 1917*

12-HOUR PERIODS

Time.	Dry matter.	Water.	Nitrogen in dry matter.	Ash in dry matter.	Wet weight.	Dry matter.	Water.	Nitrogen.	Ash.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Mgm.*	*Mgm.*	*Mgm.*	*Mgm.*	*Mgm.*
July 15, p. m.	15.9	84.1	3.75	......	1.9	0.3	1.6	0.01	.....
16, a. m.	14.5	85.5	4.19	......	2.5	.4	2.1	.02	.....
16, p. m.	17.4	82.6	4.45	7.91	3.5	.6	2.9	.03	0.05
17, a. m.	18.4	81.6	3.00	8.96	3.2	.6	2.6	.02	.05
17, p. m.	19.8	80.2	3.11	5.86	5.8	1.1	4.6	.04	.07
18, a. m.	19.2	80.8	......	6.14	7.5	1.4	6.1	......	.09
18, p. m.	20.9	79.1	......	......	8.4	1.8	6.6	......	.....
19, a. m.	21.2	78.8	......	4.02	11.6	2.5	9.1	......	.10
19, p. m.	22.8	77.2	......	4.20	13.9	3.2	10.7	......	.13
20, a. m.	22.6	77.4	......	3.80	15.8	3.6	12.2	......	.14
20, p. m.	22.2	77.8	2.27	4.63	15.8	3.5	12.3	.08	.16
21, a. m.	22.9	77.1	3.14	3.54	17.7	4.1	13.6	.13	.14
21, p. m.	25.3	74.7	......	......	20.7	5.2	15.4	......	.....
22, a. m.	25.9	74.1	2.33	3.21	25.8	6.7	19.1	.16	.21
22, p. m.	25.7	74.3	2.33	3.79	25.5	6.5	19.0	.15	.25
23, a. m.	27.6	72.2	2.18	4.18	30.9	8.6	22.3	.19	.36
23, p. m.	29.2	70.8	1.95	3.09	31.1	9.1	22.0	.18	.28
24, a. m.	29.9	70.1	2.08	3.07	31.3	9.4	22.0	.20	.29
24, p. m.	31.9	68.1	2.17	2.77	34.2	10.9	23.3	.24	.30
25, a. m.	32.1	67.9	1.96	2.88	36.3	11.7	24.6	.23	.34
25, p. m.	35.1	64.9	1.92	2.93	35.8	12.5	23.3	.24	.37
26, a. m.	35.0	65.0	2.04	2.62	36.7	12.8	23.8	.26	.34
26, p. m.	37.4	62.6	1.87	2.72	39.8	14.9	24.9	.28	.41
27, a. m.	36.6	63.4	2.04	2.61	44.3	16.2	28.1	.33	.42
27, p. m.	38.1	61.9	2.02	2.84	44.9	17.1	27.8	.35	.49
28, a. m.	37.5	62.5	2.09	2.41	47.4	17.8	29.6	.37	.43
28, p. m.	41.4	58.6	1.86	2.42	48.9	20.2	28.6	.38	.49
29, a. m.	40.0	60.0	1.86	2.49	48.4	19.3	29.0	.36	.48
29, p. m.	42.4	57.6	2.19	2.43	49.6	21.0	28.5	.46	.51
30, a. m.	42.2	57.8	2.02	2.10	51.5	21.7	29.8	.44	.46
30, p. m.	45.0	55.0	2.00	2.28	54.5	23.9	30.6	.48	.55
31, a. m.	44.1	55.9	2.09	2.41	51.7	22.8	28.9	.48	.55
31, p. m.	46.8	53.2	2.14	2.22	52.7	24.7	28.1	.53	.55
Aug. 1, a. m.	47.1	52.9	1.89	2.27	55.1	25.9	29.1	.49	.59
1, p. m.	49.1	50.9	2.08	2.25	54.5	26.7	27.7	.56	.60
2, a. m.	47.4	52.6	1.82	1.94	55.9	26.3	29.2	.48	.51
2, p. m.	49.9	50.1	1.97	2.12	50.9	25.4	25.5	.50	.54
3, a. m.	50.1	49.9	1.85	2.10	55.1	27.6	27.5	.51	.58
3, p. m.	50.4	49.6	2.04	2.00	56.5	28.5	28.0	.58	.57
4, a. m.	49.3	50.7	1.85	1.97	54.5	26.9	27.7	.50	.53
4, p. m.	52.2	47.8	2.18	1.97	58.0	30.3	27.7	.66	.60
5, a. m.	51.5	48.5	1.86	1.93	56.8	29.2	27.6	.54	.56
5, p. m.	54.3	45.7	1.91	1.94	55.1	29.9	25.1	.57	.58
6, a. m.	52.8	47.2	2.03	1.83	59.0	31.1	27.9	.63	.57
6, p. m.	57.3	42.7	1.97	1.95	54.2	31.1	23.1	.61	.61
7, a. m.	54.7	45.3	2.27	1.93	60.4	33.0	27.4	.75	.64
7, p. m.	58.0	42.0	......	1.93	55.7	32.3	23.4	......	.62
8, a. m.	56.4	43.6	2.28	1.98	59.0	33.1	25.6	.76	.66
8, p. m.	57.9	42.1	......	1.77	53.4	30.9	22.5	......	.55

TABLE IV.—*Average percentage of dry matter and water per kernel in Hannchen barley, percentage of nitrogen and ash in dry matter, and actual total weight, weight of dry matter, water, nitrogen, and ash in 12-hour and 24-hour periods at Aberdeen, Idaho, in 1917*—Continued

24-HOUR PERIODS

Time.	Dry matter.	Water.	Nitrogen in dry matter.	Ash in dry matter.	Wet weight.	Dry matter.	Water.	Nitrogen.	Ash.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Mgm.*	*Mgm.*	*Mgm.*	*Mgm.*	*Mgm.*
July 15	15.9	84.1	3.75	......	1.9	0.3	1.6	0.01	......
16	16.0	84.0	4.32	7.91	3.0	.5	2.5	.02	0.05
17	19.1	80.9	3.06	7.41	4.5	.9	3.6	.03	.06
18	20.1	79.9	......	6.14	8.0	1.6	6.4	......	.09
19	22.0	78.0	......	4.11	12.7	2.8	9.9	......	.12
20	22.4	77.6	2.27	4.22	15.8	3.5	12.3	.08	.15
21	24.1	75.9	3.14	3.54	19.2	4.6	14.5	.13	.14
22	25.8	74.2	2.33	3.50	25.7	6.6	19.1	.15	.23
23	28.5	71.5	2.07	3.64	31.0	8.8	22.2	.18	.32
24	30.9	69.1	2.13	2.92	32.7	10.1	22.6	.22	.30
25	33.6	66.4	1.94	2.91	36.0	12.1	24.0	.23	.35
26	36.2	63.8	1.96	2.67	38.2	13.9	24.4	.27	.37
27	37.4	62.6	2.03	2.73	44.6	16.6	28.0	.34	.45
28	39.5	60.5	1.98	2.42	48.2	19.0	29.1	.37	.46
29	41.2	58.8	2.03	2.46	49.0	20.2	28.8	.41	.50
30	43.6	56.4	2.01	2.19	53.0	22.8	30.2	.46	.50
31	45.5	54.5	2.12	2.32	52.2	23.7	28.5	.50	.55
Aug. 1	48.1	51.9	1.99	2.26	54.8	26.3	28.4	.52	.59
2	48.7	51.3	1.90	2.03	53.3	25.9	27.4	.49	.52
3	50.3	49.7	1.95	2.05	55.8	28.1	27.8	.55	.58
4	50.8	49.2	2.02	1.97	56.3	28.6	27.7	.58	.56
5	52.9	47.1	1.89	1.94	55.9	29.5	26.4	.56	.57
6	55.1	44.9	2.00	1.89	56.6	31.1	25.5	.62	.59
7	56.4	43.6	2.27	1.93	58.0	32.6	25.4	.75	.63
8	57.2	42.8	2.28	1.88	56.1	32.0	24.1	.76	.60

CHANGES IN WET WEIGHT PER KERNEL

The trend of the wet weight is indicated in Table III and is summarized in Table IV. The course of development is more apparent in figure 9, where the growth of kernels 5, 8, and 10 is represented graphically. The most rapid increase occurs in the first 16 days. After this time the loss of water is almost equal to the increase in dry matter. The fifth, eighth, and tenth kernels represent different sections of the spike. The order of weight is reversed during the period of growth. The tenth kernel was the first of the three to be fertilized, and it reaches a constant weight some time before the fifth kernel does.

The shift of wet weight is much more evident in figure 10, where the weights of all kernels are shown. The trend of development in the wet weight is quite parallel to that of the length, lateral diameter, and dorso-ventral diameter shown in figures 6, 7, and 8. The shift here proceeds toward the base until the fourth kernel is the heaviest, and it is only toward the last that the fifth and sixth kernels become the highest in weight. The wet weight, owing to the difference of moisture content

between the kernels at the base of the spike and those at the tip, is not an accurate indication of the storage of nutrient material. The curve of wet weight is quite similar to that published by Brenchley (*1*). The losses after maturity found by Brenchley were not evident at Aberdeen, because the sampling was not carried to the same point. Brenchley included the glumes in the weights, while at Aberdeen these were removed. As the glumes can not be removed after maturity, their removal shortens the period of study. On the other hand, the glumes themselves change

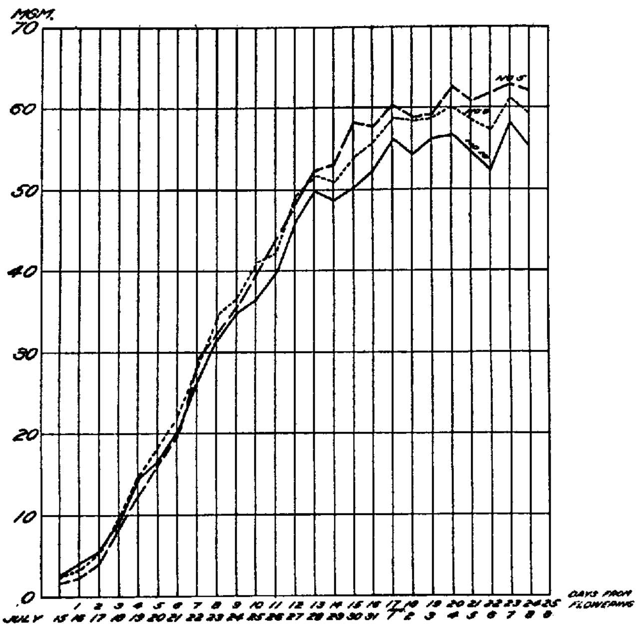


FIG. 9.—Graph showing wet weight of individual kernels 5, 8, and 10, by days, from date of flowering to near maturity in 1917.

materially in character between flowering and maturity, and their elimination removes one source of error.

INCREASE IN DRY MATTER

The daily growth of the kernel is summarized in the daily increment of dry matter. While there are gradual changes in the percentages of the various substances for days of the same week, the added constituents bear a more or less uniform relation to each other. The sum of the daily additions is the increase in dry matter. This increase has been so uniform at Aberdeen as to indicate that the plants were working very nearly at

their highest capacity. In figure 11 are given the dry-matter contents of kernels in 1916 and 1917. For the first 17 days after flowering the curves of the two years practically coincide. After the seventeenth day the rate of deposit decreases in 1917 but is maintained for several days in 1916. This is due, probably, to lack of sufficient water after this date in 1917, the effect of which is noticeable in all the results reported. The gain is surprisingly uniform for the most part. In each season, the curve is essentially a straight line from the sixth until the eighteenth

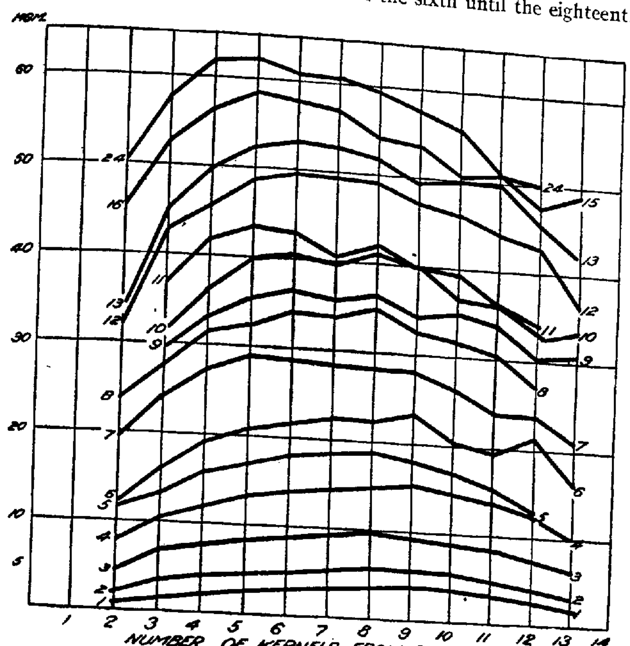


FIG. 10.—Graph showing average wet weights of kernels from flowering to maturity in plot 1 in 1917. Numerals at ends of lines indicate days from flowering.

day. This is interesting in its relation to the general laws of plant growth. In a developing plant, where the new tissue added becomes immediately productive of nutrient material for growth, the increase is accelerated in geometrical ratio. The curve of growth, in this case, can be reduced to a straight line in plotting by the use of logarithmic paper. In the case of kernel growth, by the fourth or fifth day after flowering, the maximum leaf and sheath surface is exposed. The plant food metabolized is diverted to the storage tissues of the kernel, and, since the productive tissues remain constant in amount, the curve of kernel growth is a straight line.

The uniformity of the Aberdeen seasons and the accuracy of the method of sampling used is nowhere more evident than in figure 12. In this figure the dry matter per kernel is plotted in 12-hour periods. For the first 14 days neither the error of sampling nor the differences in rate of growth of individual spikes, separately or together, exceeds the growth

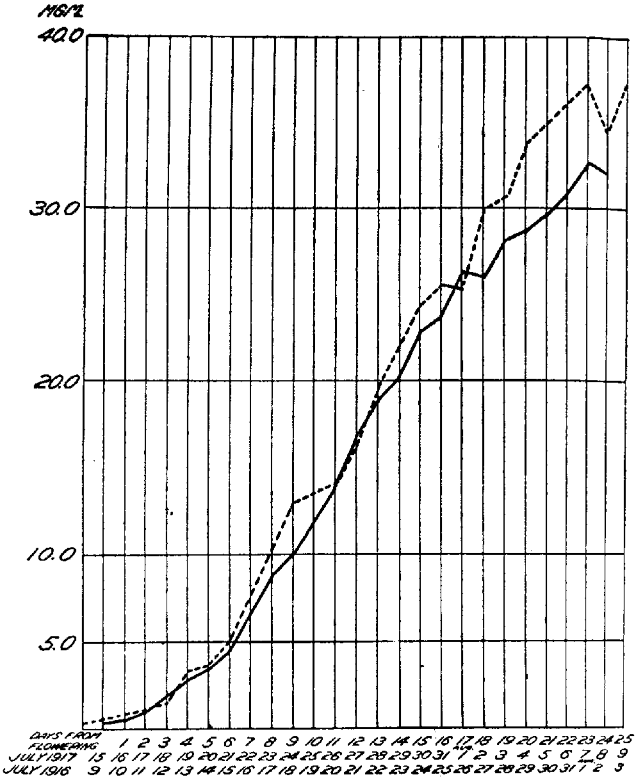


FIG. 11.—Graph showing dry matter per kernel from date of flowering to near maturity in 1916 (dotted line) and in 1917 (solid line).

in 12 hours. There is an apparent reversal of the curve in the fifth and seventh days after flowering, but the larger of these losses is less than 0.2 mgm., and in each case is due to the abnormalities of a few kernels on the spike. When this curve is plotted from the data of the more representative sixth, seventh, and eighth kernels, these irregularities disappear. It is only when the fourteenth day is reached that fluctuations

become common. After this date results are not consistent in such short periods as 12 hours.

The original purpose of the 12-hour interval was to discover, if possible, whether or not growth occurred during the night. For this reason, the periods are not quite equal. The day period consisted of about 13 hours at the beginning. As the days grew shorter this was reduced slightly. This period was thought to include the hours of effective sunlight. In figure 13 the gains and losses for the day and night periods are indicated graphically. The disadvantage of such presentation lies in the magnification of the fluctuations. For instance, the night sample of July 26 shows a decrease of 120 points, not because it is smaller than the sample of July

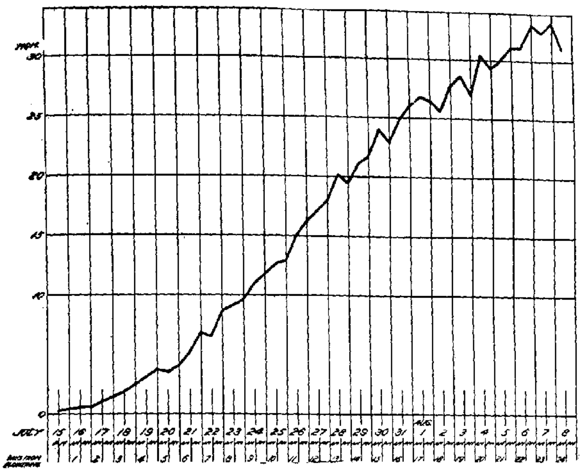


FIG. 12.—Graph showing dry matter per kernel at 12-hour intervals from flowering to maturity.

25, but because it is the same size and, therefore, no gain is registered. For the first 10 days after flowering the day and night gains appear to be nearly equal. From this time until maturity the day gain is obviously greater. The author has no interpretation to suggest, but there are two facts which may be noted. The night gains are most prominent before starch infiltration has become very active. The temperatures, after the first 10 days, are lower, the first night without gain being recorded on July 26, when the mean temperature first falls to 70° F. It is not known whether these facts have any essential relation to the results obtained or not. During the latter part of the growth period, the variation of individual spikes makes the results inconclusive.

The significant features of the data on dry-matter content are (1) the long period of daily gains following the completion of length growth,

which results in a straight line through a considerable portion of the curve when plotted, and (2) the unusual uniformity of increase which permits the taking of samples which show growth in 12-hour periods for two weeks

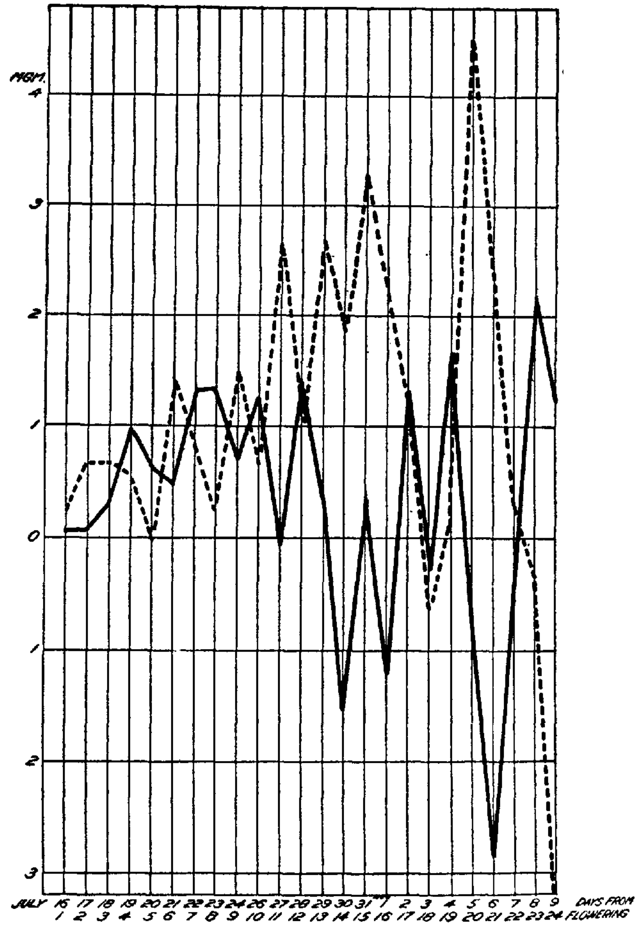


FIG. 13.—Graph showing dry-weight gain of kernels 6, 7, and 8 in 12-hour periods. Gain during the day is shown by the broken line and that during the night by the solid line.

after flowering. The curve of growth as found by Brenchley was quite similar to that shown in figure 11. The same straight line is apparent during the period of rapid starch infiltration, despite the fact that she took samples only every third day. The results seem to agree in a general

way with those of Schjerning, but inasmuch as his samples were less frequently taken, close comparison is not readily made.

CHANGES IN WATER CONTENT

The percentage of water in the kernel is highest at flowering time, when over 80 per cent of the caryopsis is water. From flowering until maturity the percentage of water constantly decreases. At maturity the water content has fallen to about 40 per cent. The decrease in percentage is very uniform, as may be seen in figure 2. The curves of 1916

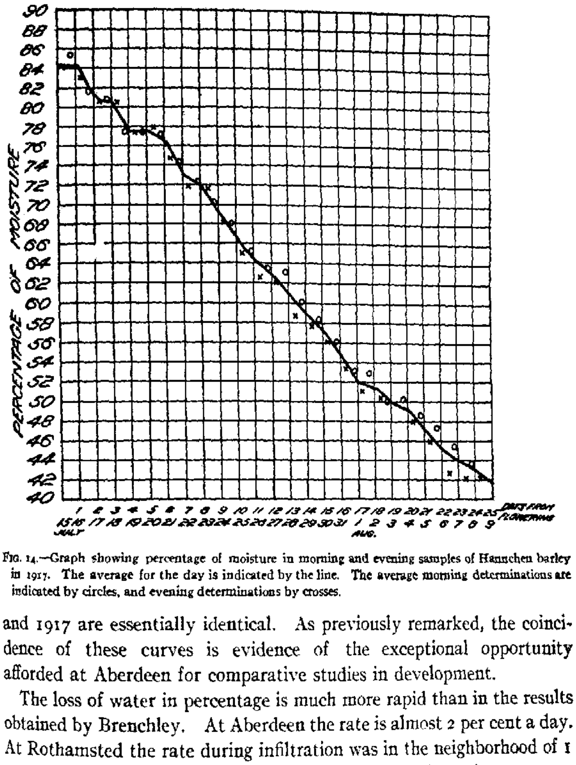


FIG. 14.—Graph showing percentage of moisture in morning and evening samples of Hannchen barley in 1917. The average for the day is indicated by the line. The average morning determinations are indicated by circles, and evening determinations by crosses.

and 1917 are essentially identical. As previously remarked, the coincidence of these curves is evidence of the exceptional opportunity afforded at Aberdeen for comparative studies in development.

The loss of water in percentage is much more rapid than in the results obtained by Brenchley. At Aberdeen the rate is almost 2 per cent a day. At Rothamsted the rate during infiltration was in the neighborhood of 1 per cent a day, although the rate was higher than this at times.

The effect of evaporation during the day was noticeable. The morning sample usually showed a gain in percentage of moisture over that of the night before. The loss of water during the day was rapid, evidently exceeding the normal loss, due to the incident of growth. This extranormal loss and its recovery are shown in figure 14.

INCREASE IN NITROGEN CONTENT

The nitrogen determinations are the least satisfactory of the studies made. The samples were so small that microchemical methods had to

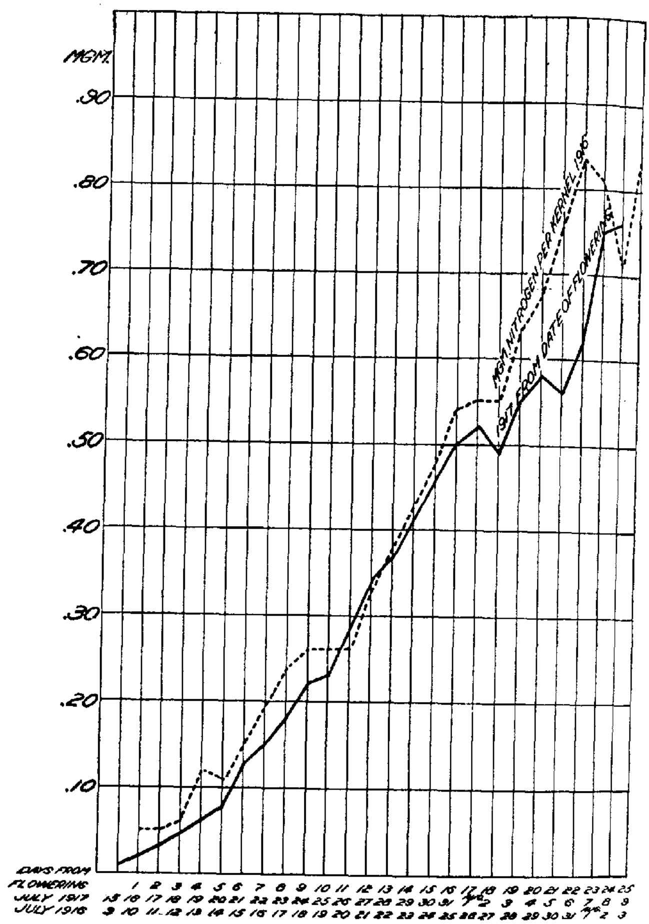


FIG. 15.—Graph showing nitrogen per kernel from date of flowering in 1916 (broken line) and in 1917 (solid line).

be used in the early stages of growth. While the material itself was probably fairly uniform, the determinations are not delicate enough to show a uniform progression in percentage. When the percentages are computed on the dry weight to obtain the milligrams of nitrogen per

grain, the results are much more uniform. In figure 15 is given the total nitrogen per kernel in both 1916 and 1917. The curves are essentially identical. The divergence after the seventeenth day is due to the lesser gain in dry matter after that time in 1917. The divergence in nitrogen content is about the same as in the dry matter shown in figure 11. The results obtained agree very closely with those of Schjerning in Denmark and Brenchley in England.

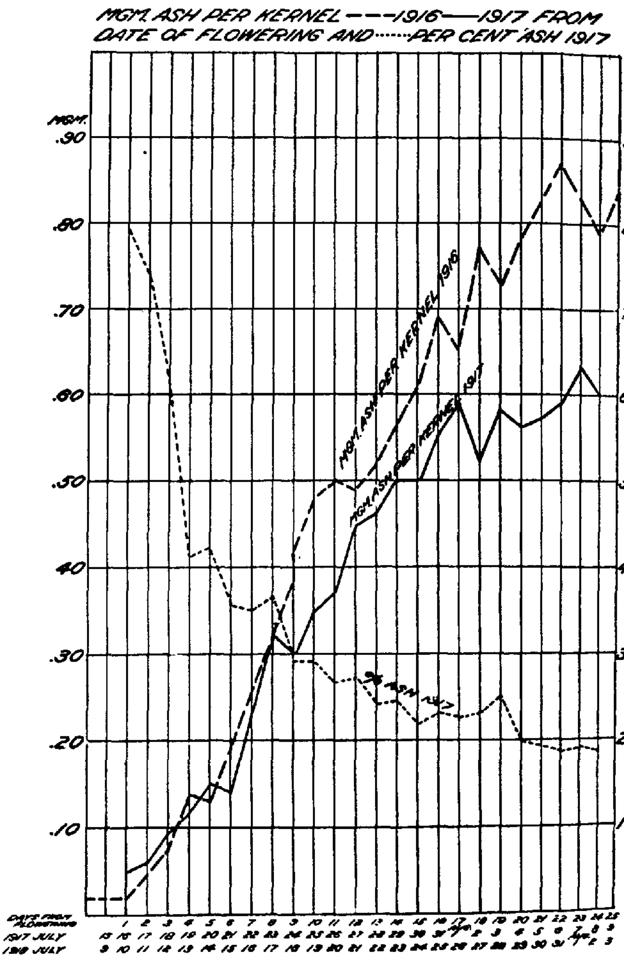
INCREASE IN ASH

The percentage of ash in the kernel decreases uniformly from flowering to maturity. At the time of fertilization the percentage is high, and for 48 hours after flowering it is more than 7 per cent. The decrease in percentage from that time is not due to loss of ash, as may be seen in figure 16, but to the more rapid increase of other materials. In other experiments, to be reported later, it has been found that the ash content is in fairly close relation to the amount of water available for the use of the plant. The curves of the ash content of 1916 and 1917 again indicate that the irrigation of 1917 was insufficient. The greater growth of 1916 has been mentioned previously; and while a part of it may have been due to better soil in 1916 a part was certainly due to the more generous irrigation of that year, coupled with the fact that the soil used in 1916 absorbed water somewhat more readily than that used in 1917.

PERIODS OF DEVELOPMENT

The Hannchen barley at Aberdeen exhibits a development which is very uniform from year to year. This development, while steadily progressive from flowering to maturity, varies considerably in its nature. The first five days after fertilization are marked by an extremely rapid growth in length. The kernel has reached its maximum in this respect by the seventh day. About the time the growth in length ceases the rapid gain in dry matter begins and continues for about two weeks. Thus the fifth or sixth day marks a change in the character of growth. About the ninth or tenth day a sticky substance is formed in the outer layers of the caryopsis, which causes the glumes to adhere thereafter to the developing kernel. The nature of this substance has not been included in this study, but its origin is evidently in the caryopsis and not in the glumes. This has been demonstrated in the making of hybrids. In this process the upper part of the florets is removed. At maturity the tips of the projecting kernels are often found stuck fast to the paper in which the spike was wrapped. The appearance of this adhesive substance on the ninth or tenth day would seem to mark a second stage of development. Since the inner tissues of the kernel are very soft, it is difficult, from this time until the kernel has somewhat hardened, to remove the glumes without tearing the kernel. This hardening occurs

about the fifteenth or sixteenth day at Aberdeen. It is accompanied by several other phenomena as well. The lemma begins to lose its color in the center of the dorsal surface. The awns of the Hannchen variety,



IG. 16.—Graph showing ash per kernel from date of flowering in 1916 (broken line) and in 1917 (solid line) and the percentage of ash in 1917 (dotted line).

hich are more or less deciduous, drop off in large numbers. The tissues f that part of the ovary above the embryo sac have been resorbed until : is possible at this stage to measure the kernel without including this

structure. The fifteenth or sixteenth day marks what probably is the most important change in the course of development. Among the internal changes, this date coincides with the maximum water content of the kernel and the end of the period of most rapid increase in dry matter and ash. Schjerning found a drop in the soluble nitrogen present in the kernel at about this time.

From the fifteenth or sixteenth day until maturity the changes are gradual and all in the same direction, differing only in degree. The only point now apparent, which might mark a change of nutrition, is to be found in those varieties which develop anthocyanin colors in the

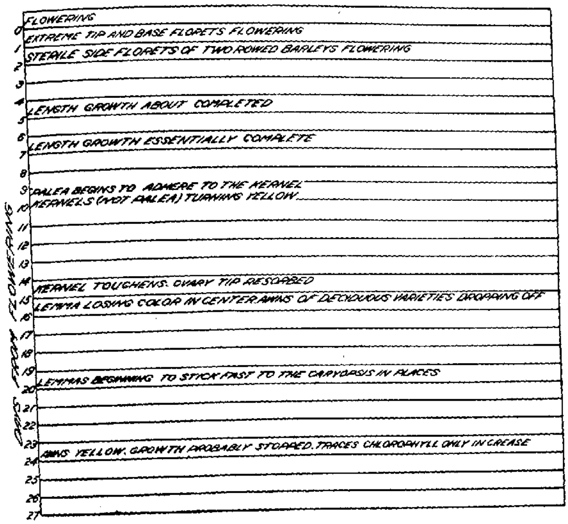


FIG. 17.—Periods of development of the barley kernel as indicated by records during three years at Aberdeen, Idaho.

external layers a few days before maturity. This is probably a very minor phase of metabolism, and at present it is not known to be associated with any vital phase of growth or maturation. The various external indices of internal changes are shown in figure 17.

MORPHOLOGICAL CHANGES

Microscopical examination of the kernel was made to determine the progress of the internal modifications that must accompany development. The starch infiltration is shown in various stages in Plates 85 to 91. Starch was found on the fourth day. This had increased perceptibly on the sixth day. The starch grains up to this time seemed

to be of a very much lower density than normal barley starch. They did not stain readily and were indefinite in outline. Rapid infiltration of starch began about the time that rapid growth of length ceased. By the ninth day after flowering the starch grains were of very uniform appearance. From this time the development was more irregular, not all the grains continuing to increase in size. By the fourteenth day small grains were apparent among the larger ones, as though new starch grains were forming. These small grains are found in the cells from this time until maturity. The fifteenth and sixteenth days represent a period when the awns are likely to drop off. The dropping of the awns, apparently, coincides with the completion of a stage of starch infiltration. From this time on, although the rate of starch deposit holds up fairly well, the accumulation is made by the continued development of only a part of the large grains and the packing of the interstices between the larger grains with smaller ones, rather than a uniform development of all grains as at first.

The first starch was found in the older cells in the middle of the flanks. It is probable that new cells are added about the periphera of the endosperm and especially near the furrow for some time. It is unlikely that new cells are added to the periphera after the fifteenth day from flowering. The new cells added near the furrow develop in a way entirely comparable to the first cells of the starch endosperm. Such cells are shown in Plate 91. After the first two weeks the transportation of food material to the sides remote from the furrow may not be so readily accomplished. Here the cells last formed may remain nearly free from starch at maturity, although the development of the cell walls demonstrates that the cells are not young.

SUMMARY

This paper presents data showing the growth of the Hannchen variety of barley from flowering to maturity, taken at 12-hour intervals. In the early stages of development, measurable growth occurs during 12-hour intervals, and during 24-hour intervals until near maturity. The period from flowering to maturity in three successive years at Aberdeen has been 26 days.

Measurements were taken of the length, lateral diameter, and dorsoventral diameter of the kernel. The growth immediately after flowering is so rapid that the increase in length is readily measurable at 12-hour intervals. The length growth is completed by the seventh day, and as soon as the rate of growth in length decreases the lateral diameter shows its most rapid increase. The dorsoventral diameter continues to increase almost until maturity. The increase in dry matter in the kernel is very uniform throughout the period of growth. The percentage of water decreases uniformly from flowering to maturity. During

growth the carbohydrates increase most rapidly and the ash least rapidly.

There are several well-marked steps in development. About the fifth or sixth day after flowering the growth in length is checked and a rapid gain in dry matter begins. About the ninth or tenth day a sticky substance is secreted, which causes the glumes to adhere to the kernel. About the fifteenth or sixteenth day the kernel toughens, the lemma begins to lose color in the dorsal surface, some of the awns drop off, and the kernel has reached its maximum water content.

Maturation occurs gradually. The cells about the furrow continue active longer than elsewhere. The actual date when growth ceases, even where the external conditions are unusually uniform, as they are at Aberdeen, must depend on the temperature and humidity at the time of ripening.

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PLATE 83

A.—Fertilized ovary.
B.—Kernel 1 day old.
C.—Kernel 2 days old.
D.—Kernel 3 days old.


A
B
C
D

Daily Development of Kernels of Hannchen Barley

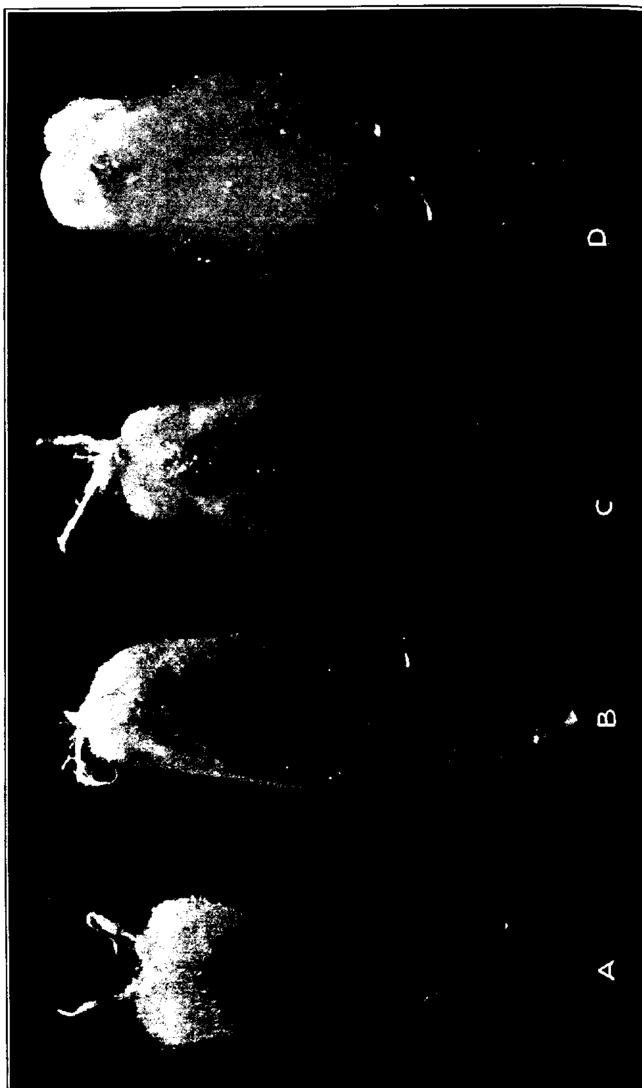

PLATE 84

A.—Kernel 4 days old.
B.—Kernel 5 days old.
C.—Kernel 6 days old.
D.—Kernel at later stage of development.

PLATE 85

Kernel 5 days after fertilization. Starch grains are apparent.

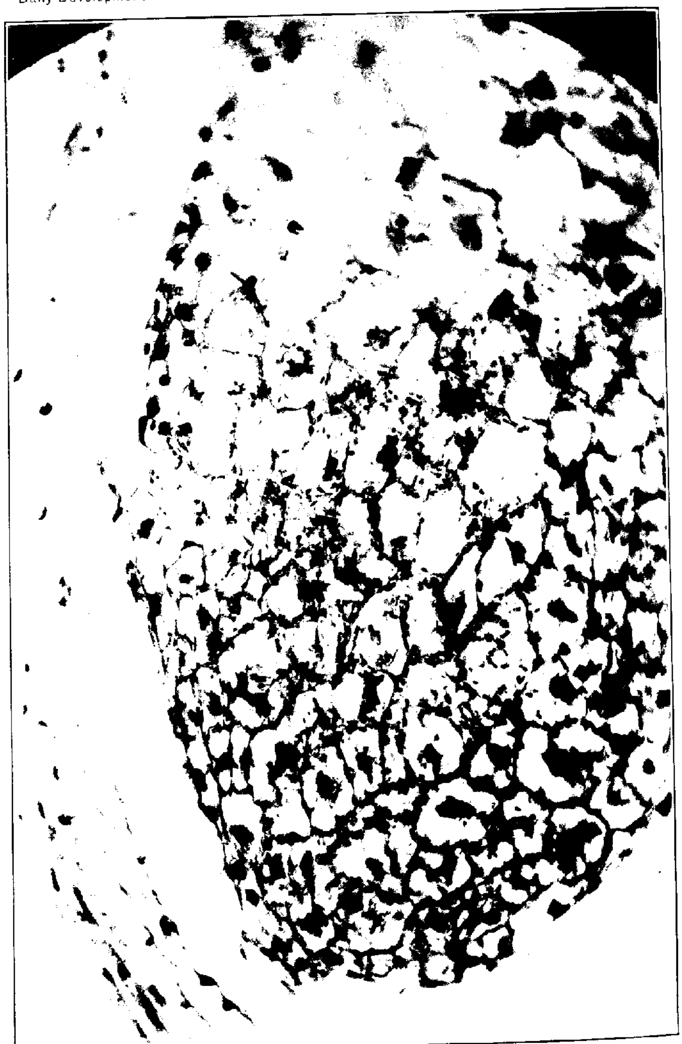

PLATE 86

Kernel 6 days after fertilization. Starch grains have increased greatly in numbers.

PLATE 87

Kernel 9 days after fertilization. The cells are well filled with starch grains of uniform size.

PLATE 88

Kernel 14 days after flowering. Both large and small starch grains are present.

PLATE 89

Kernel 20 days after fertilization, at which time growth was nearly completed.

PLATE 90

Kernel 25 days after fertilization, growth completed.

PLATE 91

Section of a nearly mature kernel, showing cells next the furrow. These cells were formed more recently than those of the main starch endosperm.

DEVELOPMENT OF BARLEY KERNELS IN NORMAL AND CLIPPED SPIKES AND THE LIMITATIONS OF AWNLESS AND HOODED VARIETIES[1]

By HARRY V. HARLAN, *Agronomist in Charge of Barley Investigations*, and STEPHEN ANTHONY, *formerly Technologist in Barley Investigations, Office of Cereal Investigations, Bureau of Plant Industry, United States Department of Agriculture*

INTRODUCTION

The studies reported in this paper were made in an effort to obtain some light on one of the farm problems in barley production. Among the farmers of the United States there is a strong prejudice against the growing of barley because the long, rough awns make the crop disagreeable to handle. The beards in barley straw and hay often cause sore mouths in stock. Barley straw and barley hay are also undesirable for feeding to sheep because the awns work into the wool. It is only the high acre yield in pounds of feed that has maintained the acreage of this crop, but this acreage is far below that which would be devoted to barley if the awns were lacking.

Certain types of barley are free from the harsh awns. One of these, the Nepal, produces hoods in the place of awns. This variety, under various names, has been more frequently introduced and more widely tested than any other. Many hybrids have been made and distributed. That they have failed to measure up to the expectations is evident in the annual inquiry of seedsmen as to where they can secure seed of "bald" barley.

The only apparent explanation of the failure of the Nepal barley is the lack of awns. The field records of the Office of Cereal Investigations, extending over many years, indicate that the Nepal compares favorably with other varieties only in the high altitudes and in dry years in the northern part of the Great Plains area. As a rule, varieties of this type have yielded less than the awned sorts and have shattered badly. It is evident that the awn is an organ that is functional under most conditions, and especially in those sections where humid weather prevails at ripening time.

Zoebl and Mikosch[2] in 1892 showed that the awn of barley was an organ of transpiration. Schmid[3] in 1898 and Perlitus[4] in 1903 elaborated the experiments of Zoebl and Mikosch. All agreed that the awn was an organ of transpiration and all showed the effect of its removal on both the rate of transpiration and the kernel.

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[1] These studies were made on the Aberdeen Substation, Aberdeen, Idaho, in connection with cereal experiments conducted cooperatively by the Idaho Agricultural Experiment Station and the Office of Cereal Investigations, Bureau of Plant Industry, United States Department of Agriculture.

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Aug. 2, 1920
Key No. G-200

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EXPERIMENTAL METHODS AND MATERIAL

The first experiment by the present writer was a very elementary one made in Minnesota in 1911. It included yield only. Plants from which the awns were clipped produced only 75 per cent of the yield of normal plants.

In this and the later experiments, sufficient spikes of the same age were tagged on the same day. The method used was that described in an earlier paper.[1] The awns on half the spikes were removed even with the top of the upper most sheath as fast as they appeared. In clipping the awns it was necessary to examine the heads each day for three or four days.

It is apparent that mechanical injuries might result from this operation which would affect the later growth of the spike. For this reason it was thought desirable to trace the growth throughout the period from flowering to maturity. The number tagged was sufficient for a sample of two or three spikes per day from both the clipped and the normal plants for a period of 30 days. In a preliminary experiment at Arlington Farm, Va., in May, 1915, it was found that the taking of daily samples was practicable. In July, 1915, a complete experiment was conducted with the Manchuria barley at University Farm, St. Paul, Minn., and in the summer of 1916 a similar experiment was conducted at Aberdeen, Idaho, with Hannchen barley. The weights, lengths, and diameters of the kernels of the samples were obtained daily. The kernels were later analyzed to determine the nitrogen and ash. The results from the two varieties will be presented separately.

EFFECT OF REMOVING THE AWNS FROM MANCHURIA BARLEY IN MINNESOTA

The Manchuria is a 6-rowed variety of barley. It is awned, a vigorous grower, and adapted to fairly humid climatic conditions. It cannot be grown in the arid districts with success. The first sample at Minnesota was taken on July 1, 1915; and samples were taken daily until August 7, with the exception of five days. This was the only study conducted in Minnesota. Table I shows the data obtained at St. Paul, Minn., in a humid district, with the variety of barley best adapted to that district. The samples taken in Minnesota differ from those taken at Aberdeen in that they consist of a single spike each day. The weights and measurements of the individual lateral and central kernels on one side of the spike were taken under each of the headings "weight," "length," etc., in Table I. The first column contains the weight and measurement of a lateral kernel, the second contains those of the central kernel, and the third contains those of the remaining lateral kernels at the same rachis node. The kernels were studied in order from the base of the spike upward. In the first line under each date are the data from the first fertile florets at the base of the spike. In the second line are the observations on the florets at the node above. The last line contains the data on the last fertile florets at the tip of the spike.

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TABLE I.—*Development of kernels of Manchuria barley from flowering to maturity in normal and clipped spikes at St. Paul, Minn., 1915*

Normal spikes.												Clipped spikes.											
Weight.			Length.			Lateral diameter.			Dorsoventral diameter.			Weight.			Length.			Lateral diameter.			Dorsoventral diameter.		
Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.
Gm.	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Gm.*	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
JULY 1																							
0.0007	0.0011	0.0007	1.9	1.9	1.8	0.6	0.6	0.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
.0009	.0011	.0009	2.0	2.2	1.9	.6	.7	.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
.0009	.0012	.0009	1.7	1.9	1.8	.7	.7	.5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
.0010	.0012	.0010	2.0	1.9	1.9	.7	.7	.7	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
.0011	.0012	.0010	1.9	1.9	2.1	.7	.8	.8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
.0012	.0014	.0009	1.7	2.2	1.9	.8	.8	.8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
.0008	.0011	.0007	2.0	2.0	1.8	.7	.7	.7	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
.0007	.0011	.0008	2.2	2.6	1.5	.7	.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
JULY 2																							
0.0009	0.0014	0.0009	2.1	2.3	1.7	0.6	0.6	0.6	...	...	...	0.0010	0.0021	0.0010	1.9	2.4	2.3	0.7	0.6	0.6	...	...	...
.0012	.0017	.0012	1.9	2.3	2.1	.6	.9	.7	...	...	...	.0011	.0023	.0012	2.1	2.6	2.2	.7	.8	.6	...	...	...
.0012	.0019	.0015	2.2	2.6	2.2	.7	.8	.8	...	...	...	.0018	.0025	.0017	2.5	2.7	2.5	.9	1.0	.8	...	...	...
.0013	.0021	.0013	2.2	2.2	2.0	.8	1.0	.6	...	...	...	.0019	.0026	.0018	2.4	2.9	2.6	.7	.9	.7	...	...	...
.0012	.0022	.0012	1.7	2.5	1.7	.8	.7	.7	...	...	...	.0020	.0027	.0019	2.4	2.7	2.6	.9	1.0	.8	...	...	...
.0012	.0019	.0015	2.2	2.5	2.2	.6	.8	.7	...	...	...	.0020	.0028	.0020	2.5	2.7	2.4	.9	.9	.8	...	...	...
.0013	.0018	.0014	2.3	2.5	2.4	.8	.8	.7	...	...	...	.0017	.0028	.0017	2.5	2.8	2.0	.8	1.0	.8	...	...	...
.0014	.0018	.0013	2.3	2.4	2.3	.7	.8	.7	...	...	...	.0015	.0024	.0016	2.2	2.2	2.3	.8	.9	.8	...	...	...
.0012	.0017	.0012	2.4	2.3	1.9	.7	.9	.8	...	...	...	.0013	.0018	.0014	1.8	2.2	2.1	.7	.7	.5	...	...	...
.0011	.0013	.0012	1.7	2.0	2.1	.7	.7	.8	...	...	...	.0008	.0011	.0008	1.7	1.9	1.5	.8	.7	.6	...	...	...
.0003	.0006	.0003	1.1	1.4	1.2	.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

TABLE I.—*Development of kernels of Manchuria barley from flowering to maturity in normal and clipped spikes at St. Paul, Minn., 1915*—Con.

JULY 3

Normal spikes.												Clipped spikes.											
Weight.			Length.			Lateral diameter.			Dorsoventral diameter.			Weight.			Length.			Lateral diameter.			Dorsoventral diameter.		
Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.
Gm.	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Gm.*	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
0.0012	0.0017	0.0006	1.9	2.2	1.2	0.5	0.8	0.0	......	......	......	0.0010	0.0015	S	1.9	2.2	S	0.7	0.7	S	......	......	......
.0013	.0020	.0013	2.0	2.3	2.0	.7	.7	.7	......	......	......	.0012	.0022	0.0013	2.0	2.4	2.0	.6	.7	.7	......	......	......
.0013	.0023	.0014	2.1	2.5	2.1	.8	.9	.7	......	......	......	.0014	.0023	.0016	2.1	2.5	2.2	.8	.8	.7	......	......	......
.0014	.0023	.0014	2.1	2.5	2.2	.8	1.0	.7	......	......	......	.0016	.0025	.0016	2.2	2.5	2.2	.6	.8	.7	......	......	......
.0014	.0018	.0014	2.0	2.2	2.1	.8	.7	.7	......	......	......	.0017	.0028	.0017	2.4	2.8	2.5	.7	1.3	.7	......	......	......
.0014	.0018	.0013	2.1	2.1	2.3	.6	.8	.6	......	......	......	.0015	.0020	.0016	2.1	2.5	2.3	.8	.7	.9	......	......	......
.0015	.0018	.0014	2.1	2.0	1.9	.7	.9	.7	......	......	......	.0016	.0019	.0015	2.1	2.4	2.0	.6	.6	.9	......	......	......
.0014	.0018	.0014	1.9	1.8	1.7	.9	.7	.7	......	......	......	.0015	.0018	.0015	2.0	1.9	1.8	.7	.8	.7	......	......	......
.0012	.0016	.0009	2.3	2.0	2.0	.8	.8	.8	......	......	......	.0012	.0016	.0012	1.8	2.1	1.9	.7	.7	.6	......	......	......
.0004	.0007	[a]S	1.4	1.4	S	.4	.8	S	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
JULY 5																							
0.0014	0.0025	0.0014	2.1	2.7	2.2	0.7	0.7	0.7	0.7	0.7	0.5	0.0014	0.0031	0.0015	2.2	2.9	2.2	0.7	1.5	0.9	0.6	0.8	0.7
.0018	.0029	.0018	2.3	2.8	2.2	.9	1.2	.8	.6	.8	.6	.0021	.0038	.0019	2.5	2.6	2.4	1.1	1.3	1.0	.7	.9	.7
.0018	.0030	.0018	2.2	3.0	2.3	.6	1.0	.6	.6	.9	.5	.0022	.0037	.0022	2.9	3.0	2.4	1.3	1.3	1.1	.8	.7	.8
.0018	.0030	.0026	2.3	2.4	2.4	.7	1.0	1.1	.6	1.0	.8	.0028	.0040	.0029	2.4	2.8	3.0	1.3	1.3	1.3	.9	.8	.8
.0018	.0031	.0019	2.2	2.2	2.2	.9	1.4	.9	.7	.8	.6	.0025	.0041	.0025	2.6	3.3	2.5	1.3	1.3	1.2	.8	.8	.8
.0018	.0029	.0019	2.3	2.1	2.3	.7	1.0	.9	.5	.9	.5	.0030	.0039	.0025	3.2	3.2	2.1	1.3	1.4	1.3	1.0	1.0	.7
.0016	.0029	.0016	2.1	2.3	2.2	.7	1.3	.8	.5	.9	.6	.0027	.0037	.0025	2.5	2.6	2.5	1.3	1.4	1.1	.8	1.0	......
.0016	.0023	.0016	2.1	2.5	2.1	.9	.9	1.0	.7	.7	.7	.0020	.0027	.0020	1.9	2.3	2.1	1.0	1.1	.9	......	......	......
.0013	.0019	.0014	1.9	2.3	1.9	.8	.9	.7	.7	.7	.6	.0016	.0020	.0014	2.2	2.0	2.1	.6	.8	.7	......	......	......
S	S	S	S	S	S	S	S	S	S	S	S	.0006	.0009	.0006	1.3	1.4	1.3	......	.6	......	......	......	......

[a] The letter S indicates a sterile spikelet.

JULY 7

0.0050	0.0098	0.0045	4.1	5.6	3.6	1.4	1.6	1.3	1.0	1.2	0.9	0.0048	0.0078	0.0052	3.7	4.5	3.8	1.4	1.8	1.3	1.1	1.1	1.0
.0062	.0108	.0055	4.4	5.2	4.1	1.6	1.8	1.5	1.0	1.3	.8	.0057	.0102	.0064	4.1	5.7	4.3	1.5	1.7	1.5	1.0	1.1	1.0
.0073	.0123	.0070	4.7	6.4	4.5	1.6	2.0	1.5	1.0	1.2	1.1	.0075	.0085	.0069	4.7	4.6	4.5	1.5	1.6	1.5	1.0	1.1	1.0
.0079	.0126	.0069	4.6	6.1	4.3	1.6	1.9	1.6	1.1	1.2	1.2	.0075	.0088	.0074	4.4	4.7	4.6	1.6	1.6	1.6	1.2	1.2	1.0
.0087	.0125	.0070	5.0	6.1	4.6	1.7	1.9	1.6	1.2	1.2	1.1	.0069	.0092	.0072	4.1	4.8	4.3	1.4	1.7	1.6	1.0	1.1	1.2
.0081	.0116	.0072	4.9	5.7	4.3	1.7	1.8	1.5	1.0	1.1	1.1	.0070	.0082	.0072	4.1	4.3	4.3	1.5	1.5	1.5	1.1	1.2	1.1
.0067	.0712	.0062	4.0	5.3	3.7	1.5	1.8	1.4	1.1	1.1	1.0	.0060	.0079	.0046	4.1	4.3	3.5	1.4	1.5	1.4	1.0	1.1	.9
.0037	.0074	.0037	2.8	4.0	2.7	1.2	1.6	1.3	.9	1.1	1.0	.0030	.0073	.0030	2.5	4.8	2.5	1.2	1.4	1.2	.9	1.1	.9
.0034	.0038	.0030	3.1	2.8	2.4	1.3	1.3	1.2	.8	.9	.9	.0023	.0032	.0021	2.7	2.5	2.3	.8	1.2	.7	.9	1.0	.6

JULY 8

0.0051	0.0095	0.0047	3.9	5.3	3.8	1.4	1.7	1.4	1.0	1.1	0.9	0.0023	0.0048	0.0020	2.2	3.7	2.2	1.0	1.3	1.0	0.7	0.8	0.7
.0080	.0100	.0063	4.9	5.6	4.3	1.6	1.8	1.4	1.0	1.1	1.1	.0033	.0072	.0036	3.0	4.7	3.4	1.2	1.7	1.4	.8	1.0	.8
.0085	.0100	.0057	4.9	4.8	4.1	1.6	1.7	1.4	1.1	1.1	1.1	.0049	.0081	.0051	3.9	4.8	4.0	1.4	1.7	1.4	1.0	1.0	.8
.0084	.0102	.0066	4.7	5.1	4.2	1.5	1.7	1.6	1.0	1.2	1.1	.0061	.0083	.0044	4.5	4.8	3.7	1.6	1.8	1.3	1.1	1.1	1.0
.0088	.0110	.0082	5.0	5.4	5.0	1.5	1.7	1.7	1.2	1.2	1.2	.0050	.0027	.0063	3.5	2.3	4.3	1.5	.7	1.5	.8	....	1.0
.0062	.0106	.0080	4.0	5.2	4.5	1.4	1.6	1.7	1.1	1.2	1.1	.0054	.0063	.0051	4.0	4.1	3.6	1.5	1.4	1.5	1.0	1.1	1.0
.0059	.0066	.0059	4.1	4.1	3.8	1.4	1.5	1.5	1.0	1.2	1.0	.0052	.0062	.0053	3.8	3.8	3.7	1.5	1.5	1.5	1.1	1.1	1.0
.0056	.0065	.0055	3.8	4.0	3.8	1.5	1.5	1.5	1.0	1.1	1.0	.0046	.0064	.0049	3.7	4.1	3.8	1.4	1.5	1.5	1.1	1.0	1.1
.0041	.0061	.0026	3.4	4.1	2.6	1.3	1.5	1.2	.8	1.1	.7	.0038	.0065	.0026	3.0	4.0	2.7	1.3	1.4	1.1	1.0	1.0	1.0
....	.0019	....	S	2.6	S	....	1.0	....	....	.7	....	.0024	.0028	.0025	2.5	2.5	2.5	1.1	1.2	1.1	.8	1.0	.9
....	....	....	....	....	....	....	....	....	....	....	....	.0014	.0021	.0014	2.1	2.4	2.2	.7	.9	.9	.7	.7	.8
....	....	....	....	....	....	....	....	....	....	....	....	S	S	S	S	S	S	S	S	S	S	S	S

JULY 9

S	0.0074	S	S	4.7	S	S	1.8	S	S	0.9	S	0.0066	0.0100	0.0068	5.1	5.9	4.9	1.6	1.7	1.7	0.9	1.0	1.0
0.0068	.0091	0.0066	4.4	4.4	4.2	1.6	1.6	1.5	1.0	1.3	1.2	.0084	.0117	.0072	5.6	6.5	5.0	1.6	1.9	1.4	1.0	1.3	1.1
.0080	.0095	.0083	4.9	5.4	5.1	1.7	1.8	1.8	1.0	1.2	1.1	.0109	.0121	.0098	6.2	6.5	5.9	1.8	1.8	1.8	1.2	1.2	1.1
.0082	.0126	.0099	4.9	6.5	5.7	1.7	2.0	1.8	1.2	1.3	1.1	.0106	.0123	.0105	6.2	6.6	5.8	1.8	2.0	1.7	1.1	1.2	1.1
.0089	.0137	.0084	5.4	6.9	4.9	1.8	1.8	1.8	1.2	1.2	1.2	.0107	.0130	.0111	6.3	6.9	6.0	2.0	1.9	1.9	1.1	1.2	1.1
.0087	.0099	.0084	5.0	5.1	4.9	1.8	1.8	1.9	1.2	1.2	1.2	.0109	.0130	.0091	6.0	6.4	5.0	1.9	1.9	1.7	1.1	1.2	1.2
.0088	.0104	.0103	5.0	5.7	5.5	1.8	1.9	2.1	1.2	1.3	1.2	.0120	.0135	.0085	6.7	6.7	5.0	1.8	1.8	1.6	....	1.3	1.2
.0086	.0125	.0101	4.7	6.3	5.6	1.7	1.9	1.9	1.2	1.3	1.2	.0082	.0146	.0088	4.7	7.2	5.0	1.5	2.0	1.7	1.1	1.2	1.1
.0072	.0102	.0047	4.2	5.0	3.3	1.5	1.7	1.4	1.1	1.2	.9	.0088	.0142	.0079	5.2	7.3	5.0	1.7	2.0	1.6	1.1	1.2	1.1
.0039	.0049	.0037	2.9	3.4	2.8	1.3	1.4	1.4	.9	.9	.9	.0049	.0087	.0049	3.6	5.0	3.8	1.4	1.7	1.3	1.0	1.2	.9
.0010	.0017	.0010	1.7	2.1	1.6	.8	.8	.9	....	....	....	.0013	.0027	.0014	1.7	2.6	1.9	.8	1.0	.9	.5	.8	.5

TABLE I.—*Development of kernels of Manchuria barley from flowering to maturity in normal and clipped spikes at St. Paul, Minn., 1915*—Con.

Normal spikes.												Clipped spikes.											
Weight.			Length.			Lateral diameter.			Dorsoventral diameter.			Weight.			Length.			Lateral diameter.			Dorsoventral diameter.		
Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.
JULY 10																							
Gm.	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Gm.*	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
0.0096	0.0129	0.0098	5.9	6.6	5.9	....	1.8	1.8	1.2	1.3	1.0	0.0069	0.0157	0.0078	5.0	7.6	5.4	1.7	2.3	1.6	1.0	1.5	1.0
.0114	.0149	.0109	6.4	7.4	6.3	2.0	2.0	1.9	1.0	1.3	1.1	.0095	.0150	.0088	5.5	7.4	6.0	1.7	2.2	1.8	1.2	1.3	1.3
.0123	.0168	.0107	6.4	7.4	5.9	2.0	2.3	1.8	1.2	1.3	1.3	.0108	.0152	.0085	6.7	7.6	5.8	1.9	2.1	1.6	1.3	1.5	1.2
.0132	.0159	.0128	6.7	7.8	6.9	2.0	2.2	2.0	1.3	1.4	1.3	.0121	.0160	.0106	7.0	8.1	6.2	1.8	2.2	1.8	1.2	1.5	1.4
.0127	.0175	.0123	7.2	8.4	6.7	2.0	2.3	2.1	1.2	1.5	1.2	.0138	.0162	.0134	7.6	7.8	7.4	1.9	2.2	2.0	1.4	1.5	1.4
.0130	.0181	.0131	6.8	8.1	6.7	1.9	2.3	1.9	1.3	1.4	1.1	.0144	.0169	.0134	7.8	8.1	7.6	2.0	2.2	2.0	1.5	1.5	1.4
.0131	.0178	.0130	6.2	8.5	7.0	2.0	2.3	2.0	1.3	1.5	1.2	Lost.	.0167	.0119	....	8.0	6.8	....	3.2	1.9	......	1.5	1.2
S	.0142	.0110	S	6.9	5.7	S	1.9	1.9	S	1.3	1.2	Dead.	.0164	.0099	....	7.8	5.6	....	2.1	1.8	......	1.4	1.1
.0078	.0135	.0070	4.3	6.6	4.4	1.6	1.6	1.6	1.1	1.3	.9	.0080	.0138	.0070	5.5	7.0	5.0	1.7	2.1	1.5	1.0	1.3	1.0
.0029	.0055	.0021	3.2	4.1	2.3	1.1	1.8	1.0	.8	.8	.6	S	S	S	S	S	S	S	S	S	S	S	S
JULY 11																							
0.0139	0.0208	0.0153	7.9	8.7	7.9	2.1	2.4	2.3	1.4	1.6	1.4	Dying.	0.0139	0.0088	....	7.7	6.2	....	2.1	1.7	......	1.5	1.2
.0186	.0213	.0172	8.4	8.6	8.1	2.3	2.4	2.2	1.6	1.6	1.6	0.0121	.0172	.0108	7.7	7.8	6.8	2.0	2.0	1.7	1.4	1.5	1.3
.0184	.0225	.0175	8.6	9.5	8.2	2.4	2.5	2.3	1.7	1.6	1.7	.0163	.0187	.0132	7.8	7.6	7.1	2.2	2.5	2.1	1.5	1.6	1.5
.0201	.0241	.0194	9.0	9.3	8.9	2.4	2.4	2.3	1.6	1.8	1.7	.0166	.0216	.0170	7.7	8.7	8.2	2.1	2.4	2.2	1.5	1.7	1.5
.0196	.0250	.0205	8.7	9.8	8.8	2.2	2.5	2.4	1.5	1.8	1.7	.0183	.0217	.0126	8.4	8.7	7.4	2.2	2.4	2.1	1.5	1.6	1.4
.0210	.0230	.0150	8.7	9.5	7.8	2.3	2.3	2.1	1.7	1.7	1.4	.0190	.0222	.0202	8.2	8.9	9.1	2.3	2.3	2.3	1.7	1.7	1.6
.0157	.0229	.0150	7.8	9.2	7.3	2.2	2.3	2.1	1.5	1.7	1.5	.0187	.0228	.0198	8.2	9.0	8.5	2.3	2.3	2.3	1.7	1.8	1.6
.0153	.0225	.0147	7.5	9.3	7.5	2.2	2.3	2.1	1.4	1.6	1.3	.0190	.0221	.0195	8.6	9.2	8.8	2.2	2.3	2.3	1.5	1.6	1.5
.0130	.0158	.0108	7.1	7.8	5.9	2.2	2.0	1.7	1.2	1.3	1.1	.0159	.0225	.0160	8.2	9.4	8.1	2.1	2.3	2.2	1.4	1.7	1.5
S	.0035	S	S	3.0	S	S	1.0	S	S	.7	S	.0099	.0157	.0093	6.1	7.8	5.0	1.7	1.9	1.6	1.0	1.4	1.0
......	......	......	......	......	......	......	......	......	......	......	......	.0022	.0043	.0019	2.5	3.4	2.1	.9	1.3	.9	.8	.8	.6

JULY 12																							
0.0182	0.0255	0.0179	8.7	9.1	8.4	2.1	2.6	2.2	1.7	1.8	1.5	0.0161	0.0248	0.0157	7.5	8.1	7.9	2.3	2.7	2.3	1.4	1.7	1.6
.0195	.0269	.0192	8.6	9.2	8.7	2.1	2.4	2.2	1.6	1.7	1.6	.0205	.0277	.0176	8.7	8.7	8.4	2.5	2.9	2.3	1.6	2.0	1.5
.0201	.0283	.0202	8.4	10.1	9.0	2.4	2.7	2.3	1.7	1.7	1.5	.0218	.0296	.0222	8.9	10.0	9.1	2.5	2.7	2.4	1.6	1.9	1.8
.0247	.0304	.0223	9.4	10.0	9.0	2.5	2.7	2.3	1.8	1.7	1.6	.0243	.0305	.0233	9.3	9.8	8.9	2.5	2.8	2.5	1.7	1.8	1.7
.0262	.0299	S	9.2	9.8	S	2.3	2.8	S	1.7	1.8	S	.0237	.0294	.0252	9.2	9.9	8.8	2.4	2.6	2.6	1.7	1.8	1.7
.0215	.0295	.0214	9.1	10.2	8.5	2.4	2.7	2.5	1.6	1.7	1.6	.0243	.0325	.0268	9.0	10.7	9.2	2.7	2.7	2.5	1.7	1.8	1.9
.0213	.0240	.0207	9.1	9.9	9.3	2.4	2.4	2.3	1.6	1.7	1.5	.0217	.0218	.0235	8.7	8.4	9.0	2.4	2.5	2.3	1.6	1.6	1.7
.0170	.0211	.0132	8.4	9.2	6.9	2.2	2.4	1.9	1.4	1.4	1.2	.0222	.0279	.0256	8.8	10.0	9.7	2.5	2.5	2.4	1.7	1.8	1.8
S	S	S	S	S	S	S	S	S	S	S	S	.0231	.0283	.0232	9.0	10.4	9.1	2.4	2.5	2.4	1.6	1.9	1.9
												.0182	.0244	.0199	8.0	9.9	9.1	2.2	2.5	2.2	1.7	1.8	1.7
												.0060	{.0095 .0080}	.0060	4.6	{6.1 6.1}	4.8	1.4	{1.5 1.6}	1.6	.8	{.9 1.0}	.8
JULY 13																							
0.0195	0.0245	S	8.2	8.7	S	2.4	2.6	S	1.6	1.7	S	0.0184	0.0315	0.0187	8.3	8.9	7.9	2.3	2.9	2.5	1.4	1.9	1.3
.0215	.0325	0.0230	9.0	9.9	8.7	2.2	2.9	2.6	1.7	2.0	1.7	.0265	.0370	.0257	8.5	9.3	8.8	2.6	3.1	2.7	1.6	1.9	1.7
.0233	.0314	.0234	8.9	9.7	9.1	2.5	3.0	2.3	1.7	1.8	1.6	.0276	.0407	.0287	8.7	9.6	9.2	2.7	3.0	2.7	1.9	2.1	2.1
.0244	.0316	.0237	9.2	9.8	8.8	2.5	2.7	2.7	1.7	1.8	1.6	.0310	.0419	.0300	9.2	10.5	9.3	2.8	3.3	2.8	1.8	2.2	1.8
.0260	.0337	.0267	9.1	10.0	9.9	2.7	2.9	2.8	1.8	1.8	1.6	.0326	.0400	.0320	8.8	9.9	9.2	2.9	3.2	2.9	1.8	1.9	2.1
.0254	.0290	.0259	9.5	9.5	9.0	2.7	2.7	2.5	1.8	1.8	1.9	.0368	.0440	.0328	9.5	10.5	9.4	3.2	3.3	2.9	2.1	2.2	1.8
.0263	.0339	.0252	9.2	10.2	9.0	2.6	2.7	2.5	1.9	2.1	1.6	.0326	.0396	.0340	9.5	10.0	9.1	2.8	3.1	2.9	1.8	2.3	1.9
.0246	.0285	.0277	9.4	10.0	9.2	2.4	2.6	2.8	1.6	1.8	1.9	.0337	.0376	.0334	9.9	10.5	9.9	2.8	3.0	3.0	1.8	2.0	2.0
.0131	.0238	.0150	7.3	9.4	7.2	2.0	2.2	2.1	1.3	1.4	1.3	.0258	.0403	.0292	9.3	10.6	9.5	2.6	3.0	2.7	1.8	2.0	2.0
												.0179	.0331	.0212	8.8	10.5	8.4	2.0	2.7	2.4	1.5	2.0	1.6
JULY 14																							
0.0269	0.0330	0.0263	8.8	9.6	8.8	3.0	3.0	2.5	1.7	2.0	1.9	0.0224	0.0369	0.0238	8.1	9.3	7.9	2.6	3.3	2.7	1.9	2.1	1.8
.0320	.0391	.0338	9.4	10.0	9.6	2.9	3.0	3.0	2.0	2.1	2.1	.0293	.0373	.0254	8.5	9.4	8.7	3.0	3.4	2.7	1.9	2.3	2.0
.0338	.0427	.0338	9.2	10.3	9.5	3.0	3.3	2.9	2.0	2.2	2.1	.0314	.0426	.0300	9.0	10.1	9.0	3.1	3.4	3.0	1.9	2.3	2.2
.0352	.0452	.0363	9.6	10.6	9.6	3.1	3.3	2.9	2.1	2.2	2.4	.0324	.0454	.0331	9.0	10.1	9.1	3.2	3.6	3.2	2.0	2.6	2.3
.0372	.0428	.0384	10.0	10.6	9.4	3.1	3.3	3.2	2.4	2.2	2.3	.0323	.0390	.0338	9.0	10.7	9.4	3.2	3.2	3.2	2.0	2.2	2.2
.0358	.0445	.0379	9.8	10.5	9.7	2.8	3.2	2.9	2.0	2.3	2.0	.0321	.0410	.0319	9.7	10.1	9.3	2.2	3.2	3.0	1.9	2.0	1.8
.0226	.0450	.0293	9.2	10.6	9.7	2.7	3.0	2.8	1.7	2.4	1.8	.0307	.0406	.0282	9.5	10.9	8.7	2.9	3.2	2.8	1.9	2.0	1.8
.0259	.0410	.0306	9.8	10.9	9.8	2.7	3.1	2.8	2.1	2.3	2.0	.0217	.0330	S	9.1	10.6	S	2.5	2.8	S	1.8	1.8	S
.0253	.0329	S	9.1	9.9	S	2.5	2.8	S	1.6	1.9	S	S	S	S	S	S	S	S	S	S	S	S	S
S	S	S	S	S	S	S	S	S	S	S	S												

TABLE I.—*Development of kernels of Manchuria barley from flowering to maturity in normal and clipped spikes at St. Paul, Minn., 1915*—Con.

Normal spikes.												Clipped spikes.											
Weight.			Length.			Lateral diameter.			Dorsoventral diameter.			Weight.			Length.			Lateral diameter.			Dorsoventral diameter.		
Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.
JULY 15																							
Gm.	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Gm.*	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
0.0335	0.0589	0.0320	8.6	9.5	8.6	3.0	3.6	3.1	2.1	2.4	2.1	0.0238	0.0363	0.0258	8.6	8.6	8.4	2.8	3.3	2.9	1.6	2.1	2.0
.0390	.0462	.0352	9.4	9.8	9.5	3.0	3.5	3.1	2.2	2.5	2.0	.0346	.0358	.0301	9.0	8.6	8.9	3.1	3.4	3.1	2.1	2.3	1.9
.0410	.0505	.0337	9.2	10.0	9.5	3.7	3.5	3.4	......	2.3	2.3	.0376	.0452	.0341	9.1	9.5	9.0	3.1	3.4	3.1	2.3	2.3	2.0
.0448	.0406	.0431	9.5	9.8	9.5	3.5	3.5	3.4	2.3	2.2	2.2	.0389	.0448	.0385	9.7	9.5	9.3	3.3	3.3	3.3	2.0	2.2	2.2
.0448	.0517	.0420	9.5	10.2	9.5	3.4	3.6	3.2	2.2	2.2	2.1	.0390	.0488	.0403	9.4	10.3	9.7	3.3	3.5	3.3	2.3	2.3	2.2
.0458	.0537	.0454	9.9	10.5	9.6	3.4	3.5	3.4	2.3	2.2	2.2	.0397	.0498	.0400	9.6	10.0	9.6	3.2	3.7	3.2	2.0	2.3	2.2
.0455	.0533	.0438	10.3	10.4	9.6	3.5	3.7	3.3	2.1	2.3	2.3	.0369	.0374	.0444	9.5	10.7	a Dec.	3.1	3.0	3.4	2.0	2.0	2.3
S	.0462	.0384	S	11.0	10.1	S	3.2	3.2	2.4	2.3	2.0	.0358	.0496	.0365	9.9	10.5	9.6	3.1	3.4	3.0	1.8	2.3	2.1
.0342	.0423	.0292	9.5	10.8	9.6	2.9	3.2	2.9	1.9	2.2	1.8	.0279	.0390	.0324	9.5	10.8	9.9	2.7	3.2	2.8	1.9	2.2	2.0
S	S	S	S	S	S	S	S	S	S	S	S	.0098	{ .0188 .0170 }	S	6.7	{ 9.0 8.3 }	S	1.8	{ 2.4 2.2 }	S	1.0	{ 1.7 1.5 }	S
JULY 16																							
Dec.	0.0404	0.0287	Dec.	9.3	9.0	......	3.4	2.9	......	2.4	2.0	S	0.0274	S	S	7.4	S	S	3.2	S	S	2.0	S
.0325	.0444	.0343	9.3	9.7	9.1	3.0	3.6	3.1	2.0	2.4	2.1	0.0305	.0435	0.0305	9.0	9.6	8.6	3.0	3.7	3.0	1.8	2.7	1.8
.0407	.0480	.0333	9.3	10.1	9.6	3.3	3.6	3.1	2.3	2.5	2.0	.0350	.0436	.0358	9.1	10.3	9.0	3.1	3.6	3.2	2.0	2.4	2.0
.0400	.0522	.0398	10.0	10.4	9.6	3.3	3.8	3.4	2.0	2.4	2.2	.0366	.0445	.0356	9.0	9.8	9.1	3.4	3.4	3.3	2.2	2.4	2.1
.0388	.0511	.0422	9.3	11.0	10.0	3.2	3.7	3.3	2.3	2.5	2.3	.0382	.0492	.0391	9.2	10.7	9.9	3.3	3.6	3.2	2.0	2.4	2.1
.0423	.0537	.0420	9.9	10.7	10.3	3.3	3.7	3.4	2.2	2.5	2.2	.0395	.0453	.0378	9.6	10.2	9.1	2.4	3.4	3.2	2.2	2.4	2.2
.0439	.0531	.0372	9.6	11.1	9.9	3.4	3.8	3.2	2.3	2.5	1.9	.0397	.0465	.0385	10.0	10.5	9.1	3.3	3.3	3.6	2.2	2.0	2.0
.0430	.0475	.0401	9.9	10.6	10.3	3.3	3.4	3.2	2.3	2.4	2.1	.0346	.0495	.0365	9.5	11.0	9.8	3.0	3.5	3.2	2.0	2.1	2.0
.0322	.0420	.0313	9.3	10.3	9.1	2.9	3.1	2.8	1.9	2.1	1.9	.0310	.0392	.0330	9.3	10.2	9.7	3.0	3.2	3.0	1.9	2.2	1.9
S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

a Decayed.

JULY 17

0.0292	0.0384	0.0324	8.7	9.2	9.0	3.0	3.2	3.0	2.0	2.2	2.2	0.0329	0.0480	0.0349	9.6	9.6	8.7	3.5	3.6	3.4	2.4	2.4	2.2
.0379	.0506	.0406	9.3	10.2	9.4	3.4	3.8	3.6	2.1	2.6	2.3	.0282	.0518	.0389	8.4	9.9	8.7	3.1	3.9	3.5	2.2	2.6	2.3
.0417	.0539	.0419	9.7	10.4	9.4	3.7	3.8	3.6	2.4	2.8	2.5	.0446	.0540	.0451	9.3	10.0	9.3	3.6	4.0	3.6	2.5	3.0	2.5
.0421	.0526	.0445	9.3	10.4	9.7	3.5	3.7	3.5	2.5	2.5	2.5	.0437	.0543	.0448	9.1	10.4	9.7	3.4	3.8	3.5	2.5	2.6	2.5
.0444	.0528	.0458	9.3	10.6	9.6	3.6	3.7	3.6	2.3	2.5	2.4	.0478	.0557	.0401	9.3	10.4	9.4	3.7	3.7	3.4	2.6	2.6	2.5
.0473	.0550	.0432	9.7	10.7	10.1	3.4	3.7	3.7	2.5	2.6	2.5	.0440	.0559	.0412	9.4	10.4	9.4	3.6	3.8	3.4	2.4	2.6	2.4
.0391	.0573	.0430	9.3	10.7	10.0	3.3	3.7	3.4	2.2	2.7	2.1	S	.0572	.0457	S	10.7	9.9	S	3.7	3.6	S	2.7	2.4
.0402	.0554	.0378	10.0	10.9	9.9	3.3	3.6	3.2	2.1	2.5	2.3	.0441	.0563	.0438	9.9	10.7	9.3	3.5	3.7	3.4	2.3	2.7	2.2
.0310	.0437	.0358	9.4	10.2	9.3	3.0	3.5	3.0	2.0	2.1	2.2	.0307	.0466	.0320	9.1	10.7	9.6	3.0	3.5	[illegible]	1.9	2.5	2.2
S	S	S	S	S	S	S	S	S	S	S	S	......	......	......	......	......	......	......	......	1.2	......	......	.4

JULY 19

0.0317	0.0450	0.0310	8.8	9.4	9.2	3.2	3.6	3.0	2.3	2.5	2.2	S	0.0310	0.0225	S	8.5	8.2	S	3.0	S	S	2.0	1.9
.0344	.0509	.0296	8.9	9.6	8.8	3.2	3.8	3.0	2.2	2.6	2.0	0.0298	.0401	.0276	8.5	9.0	8.7	3.2	3.3	3.0	2.2	2.2	2.0
.0412	.0552	.0378	9.3	9.4	9.0	3.6	4.0	3.3	2.4	2.9	2.3	.0356	.0457	.0325	8.7	9.5	8.7	3.4	3.8	3.2	2.1	2.6	2.3
.0446	.0543	.0457	9.2	9.4	9.3	3.5	3.8	3.6	2.4	2.7	2.4	.0381	.0458	.0400	8.5	9.3	9.0	3.5	3.5	3.4	2.3	2.5	2.4
.0508	.0553	.0472	9.6	9.6	9.9	3.8	3.9	3.6	2.5	2.6	2.4	.0421	.0535	.0443	9.5	9.9	9.7	3.5	3.9	3.5	2.5	2.7	2.3
.0545	.0637	.0493	9.7	10.6	9.7	3.8	4.0	3.5	2.6	2.7	2.5	.0457	.0593	.0487	9.2	10.2	9.8	3.5	4.0	3.8	2.4	2.7	2.4
.0530	.0664	.0554	9.7	10.6	9.9	3.7	3.9	3.8	2.5	2.8	2.6	.0439	.0553	.0490	9.3	10.2	10.2	3.6	8.8	3.7	2.3	2.4	2.3
.0456	.0576	.0498	9.6	10.8	10.2	3.5	3.7	3.6	2.3	2.7	2.5	.0472	.0578	.0445	9.6	10.6	9.9	3.7	3.8	3.6	2.3	2.5	2.5
.0498	.0635	.0429	9.7	11.0	9.7	3.6	3.9	3.2	2.3	2.7	2.3	.0408	.0592	.0485	9.2	10.2	9.7	3.4	3.9	3.8	2.3	2.4	2.4
.0375	.0731	.0349	9.2	10.2	9.0	3.2	3.6	3.2	2.1	3.9	2.1	.0385	.0553	.0410	9.2	10.4	9.7	3.3	3.7	3.4	2.2	2.7	2.3
S	S	S	S	S	S	S	S	S	S	S	S	.0333	.0547	.0385	9.8	10.5	9.8	3.2	3.7	3.4	2.0	2.6	2.3
......	......	......	......	......	......	......	......	......	......	......	......	S	S	S	S	S	S	S	S	S	S	S	S

JULY 20

0.0388	0.0509	0.0334	9.1	9.2	8.9	3.4	3.5	3.1	2.3	2.7	2.2	0.0301	0.0458	0.0294	8.1	8.4	7.7	3.1	3.7	3.1	1.9	2.5	2.0
.0395	.0531	.0377	9.0	9.6	9.1	3.2	3.7	3.1	2.3	2.8	2.3	.0230	.0280	.0395	7.5	7.7	8.8	3.2	3.2	3.6	1.7	1.9	2.3
.0385	.0524	.0473	9.3	9.5	9.2	3.4	3.8	3.6	2.3	2.5	2.5	.0231	.0427	.0427	7.8	8.8	8.7	2.8	3.6	3.4	1.8	2.5	2.5
.0423	.0618	.0512	9.3	9.9	9.5	3.7	3.9	3.5	2.6	2.7	2.5	.0446	.0473	.0407	8.9	9.0	8.8	3.5	3.7	3.3	2.3	2.4	2.3
.0495	.0643	.0494	9.5	10.2	10.0	3.6	4.0	3.5	2.4	2.7	2.3	.0402	.0550	.0456	9.4	9.4	9.1	3.4	3.9	3.5	2.3	2.7	2.5
.0513	.0627	.0523	9.7	10.0	9.7	3.6	3.7	3.7	2.6	2.7	2.7	.0445	.0528	.0474	9.1	10.0	9.0	3.5	3.7	3.7	2.5	2.6	2.3
.0519	.0605	.0481	9.8	10.8	9.6	3.7	3.9	3.5	2.4	2.5	2.3	.0373	.0624	.0521	9.1	10.1	9.4	3.2	4.1	3.7	2.1	2.7	2.5
.0510	.0613	.0467	9.8	10.5	9.5	3.6	3.8	3.6	2.5	2.6	2.1	.0438	.0600	.0440	8.7	10.4	8.8	3.5	3.8	3.6	2.3	2.8	2.3
.0354	.0423	.0307	9.2	10.0	8.5	3.2	3.4	3.0	1.9	2.2	1.8	.0356	.0508	.0407	8.7	10.2	8.9	3.1	3.7	3.5	2.2	2.5	2.2
S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

TABLE I.—*Development of kernels of Manchuria barley from flowering to maturity in normal and clipped spikes at St. Paul, Minn., 1915*—Con.

Normal spikes.												Clipped spikes.											
Weight.			Length.			Lateral diameter.			Dorsoventral diameter.			Weight.			Length.			Lateral diameter.			Dorsoventral diameter.		
Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.
JULY 21																							
Gm.	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Gm.*	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
0.0247	0.0410	0.0267	8.7	9.2	8.7	2.8	3.5	3.0	1.9	2.5	1.8	S	0.0282	S	S	7.8	S	S	3.2	S	S	2.0	S
.0348	.0505	.0368	8.9	9.2	8.7	3.2	3.8	3.4	3.2	2.7	2 5	0.0359	.0396	0.0283	8.4	8.9	8.4	3.5	3.7	3.3	2.1	2.4	2.2
.0396	.0537	.0442	9.0	9.2	9.0	3.5	3.8	3.7	2.4	2.7	2.5	.0420	.0522	.0366	8.4	9.9	9.0	3.6	3.9	3.3	2.5	2.5	2.3
.0470	.0572	.0495	9.4	9.9	9.4	3.6	4.0	3.8	2.6	2.8	2.6	.0425	.0547	.0409	9.0	9.5	8.6	3.6	3.9	3.7	2.5	2.7	2.4
.0481	.0549	.0466	9.4	10.3	9.6	3.8	3.9	3.7	2 6	2.7	2.4	.0472	.0557	.0445	8.8	10.0	9.1	3.7	3.8	3.6	2.6	2.6	2.4
.0491	.0598	.0517	9.6	10.0	9.4	3.5	4.0	3.7	2.5	2.8	2.8	.0478	.0642	.0475	9.2	10.1	9.5	3.7	4.0	3.7	2.7	2.9	2.6
.0392	.0485	.0464	9.8	10.2	9.2	3.3	3.8	3.7	2.3	2.7	2.6	.0470	.0615	.0496	9.3	10.6	9.8	3.7	3.9	3.7	2.4	2.8	2.6
.0500	.0638	.0492	9.5	11.0	9.7	3.7	3.9	3.8	2.5	2.7	2.5	.0313	.0595	.0461	8.7	10.6	9.8	3.3	4.0	3.8	2.0	2.7	2.5
.0466	.0611	.0443	9.5	11.0	9.3	3.5	3.8	3.5	2.3	2.6	2.3	.0275	.0584	.0440	8.3	9.7	8.8	2.8	3.8	3.5	1.8	2.8	2.4
.0353	S	.0242	9.3	S	9.7	3.1	S	2.8	2.0	S	1.8	S	S	S	S	S	S	S	S	S	S	S	S
S	S	S	S	S	S	S	S	S	S	S	S												
JULY 22																							
0.0418	0.0493	0.0358	8.7	9.1	8.4	3.6	3.7	3.3	2.5	2.8	2.3	S	0.0410	0.0377	S	8.4	8.2	S	3.4	3.6	S	2.6	2.4
.0428	.0564	.0461	9.2	9.2	8.7	3.7	4.0	3.6	2.5	3.0	2.6	S	.0614	.0503	S	9.7	9.2	S	4.0	3.8	S	3.1	2.8
.0468	.0639	.0471	9.3	9.8	9.1	3.7	4.2	3.6	2.6	2.8	2.5	0.0518	.0497	.0516	9.0	9.1	9.0	3.7	4.0	3.8	2.8	2.7	2.8
.0554	.0672	.0485	9.6	9.8	9.3	4.0	4.1	3.8	2.7	3.0	2.7	.0547	.0681	.0517	9.4	10.2	9.2	3.8	4.3	3.9	3.0	3.2	2.7
.0480	.0655	.0547	9.6	10.2	9.5	3.7	4.0	3.9	2.5	3.0	2.8	.0584	.0664	.0566	9.0	9.2	9.2	4.1	4.2	3.8	3.0	2.9	2.8
.0597	.0682	.0588	10.0	10.6	9.4	3.9	4.0	4.0	2.8	3.0	2.9	S	.0655	.0613	S	10.2	9.8	S	4.1	4.0	S	3.0	3.0
.0462	.0625	.0533	9.2	10.7	9.8	3.7	3.9	3.7	2.6	2.7	2.6	.0630	.0665	.0636	9.9	10.2	9.2	4.0	3.9	4.1	3.0	2.8	3.0
.0507	.0622	.0500	9.9	11.1	9.9	3.8	3.9	3.8	2.5	2.7	2.7	.0537	.0691	.0567	9.8	9.5	9.3	3.5	3.9	3.7	2.8	2.8	2.8
S	.0563	.0448	S	10.2	9.2	S	3.8	3.8	S	2.7	2.3	S	.0728	S	S	10.3	S	S	4.2	S	S	3.0	S
																	S			S			S
S	S	S	S	S	S	S	S	S	S	S	S	S	.0666	.0517	S	10.6	9.3	S	4.0	3.7	S	3.0	2.7
												S	S	S	S	S	S	S	S	S	S	S	S

JULY 23

0.0429	0.0520	0.0435	8.7	8.2	8.9	3.6	3.8	3.7	2.3	2.8	2.4	0.0345	0.0468	0.0289	8.1	9.0	8.5	3.2	3.6	3.1	2.3	2.4	2.1
.0510	.0602	.0462	9.0	9.7	8.9	3.7	4.0	3.7	2.7	2.9	2.5	.0367	.0448	.0350	8.4	9.3	8.2	3.4	3.6	3.4	2.2	2.5	2.3
.0551	.0651	.0532	9.0	9.6	9.6	3.8	4.2	3.8	2.7	2.9	2.7	.0276	.0470	.0319	7.8	9.0	8.3	3.1	3.7	3.2	2.0	2.5	2.1
.0540	.0637	.0558	9.7	9.6	9.5	3.9	4.1	3.7	2.7	3.0	2.7	.0440	.0574	.0422	9.0	9.4	8.7	3.6	3.8	3.5	2.3	2.7	2.4
.0561	.0639	.0555	9.2	10.1	9.3	3.9	4.1	3.8	2.7	2.9	2.7	.0468	.0576	.0368	10.0	9.5	8.7	3.7	3.8	3.4	2.5	2.7	2.3
.0520	.0729	.0437	9.5	10.5	8.9	3.9	4.1	3.6	2.5	3.0	2.3	.0441	.0592	S	9.2	10.0	S	3.5	3.8	S	2.5	2.6	S
.0558	.0684	.0529	9.6	10.6	9.5	3.8	4.0	3.8	2.7	2.9	2.4	.0437	.0667	.0396	9.2	10.5	8.4	3.3	4.1	3.3	2.3	2.8	2.4
.0520	.0703	.0531	9.4	10.7	9.5	3.8	3.9	3.8	2.5	3.0	2.6	.0453	.0625	.0398	9.1	10.3	8.6	3.5	3.8	3.4	2.4	2.7	2.3
.0477	.0599	S	9.5	10.5	S	3.6	3.8	S	2.4	2.6	S	.0462	.0573	.0327	9.2	10.1	8.3	3.6	3.7	3.0	2.5	2.7	2.1
S	.0258	S	S	8.6	S	S	2.9	S	S	1.7	S	....	....	....	....	....	....	....	....	....	....	....	....

JULY 24

....	0.0415	0.0331	....	9.6	9.0	....	3.4	3.1	....	2.3	2.2	0.0329	0.0369	0.0323	8.3	8.3	8.2	3.3	3.4	3.2	2.4	2.5	2.3
0.0352	.0485	.0391	9.0	9.4	9.0	3.3	3.7	3.6	2.2	2.6	2.5	.0401	.0586	.0404	8.4	9.2	8.6	3.7	4.0	3.7	2.4	2.8	2.5
.0389	.0544	.0393	9.2	9.6	9.2	3.5	3.7	3.5	2.3	2.8	2.2	.0407	.0548	.0350	8.7	9.4	8.2	3.6	3.8	3.4	2.5	2.8	2.4
.0463	.0535	.0497	9.0	10.2	9.3	3.6	3.6	3.9	2.5	2.7	2.7	.0468	.0594	.0420	9.0	9.6	8.9	3.6	4.0	3.5	2.5	3.0	2.4
.0462	.0524	.0490	9.6	9.3	9.2	3.6	4.1	3.5	2.5	2.6	2.6	.0501	.0576	.0537	9.3	9.5	9.0	3.7	3.9	3.6	2.5	2.6	2.6
.0474	.0613	.0538	9.4	10.5	9.4	3.5	4.0	3.8	2.5	2.8	2.7	.0552	.0642	.0417	9.0	10.0	9.1	3.8	3.9	3.5	2.7	2.9	2.5
.0487	.0620	.0529	9.6	10.7	10.0	3.6	4.0	3.6	2.5	2.8	2.6	.0548	.0682	.0487	9.4	10.2	9.5	3.8	4.0	3.4	2.5	2.8	2.5
.0475	.0576	.0487	9.6	11.0	9.6	3.7	3.7	3.6	2.6	2.6	2.4	.0474	.0669	.0509	9.2	10.6	9.5	3.4	4.1	3.7	2.5	2.9	2.5
.0418	.0567	.0446	9.4	10.8	9.4	3.3	3.7	3.4	2.4	2.7	2.0	.0390	.0481	.0359	8.7	10.1	9.2	3.3	3.5	3.3	2.1	2.5	2.4
S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

JULY 26

0.0397	0.0547	0.0482	8.4	9.2	8.9	3.3	3.7	3.6	2.3	2.8	2.7	0.0348	0.0512	0.0315	8.4	8.7	8.1	3.4	3.7	3.2	2.2	2.7	2.1
.0372	.0552	.0513	8.7	9.6	8.5	3.3	3.8	3.8	2.4	2.6	2.7	.0411	.0544	.0400	8.8	9.0	8.5	3.6	3.8	3.3	2.3	2.7	2.2
.0339	.0643	.0503	8.7	9.6	9.3	3.2	3.8	3.7	2.1	2.9	2.7	.0333	.0563	.0390	8.4	9.5	8.8	3.4	4.0	3.2	2.1	2.1	2.3
.0456	.0630	.0600	9.0	9.5	9.2	3.5	4.0	3.9	2.5	2.8	2.8	S	.0506	.0456	S	9.4	8.3	S	3.0	3.5	S	2.5	2.5
.0500	.0674	.0486	9.0	9.8	8.8	3.7	3.8	3.7	2.5	2.9	2.6	.0479	.0596	.0442	9.0	9.7	9.0	3.6	3.7	3.5	2.5	2.8	2.5
S	.0494	.0472	S	10.0	9.2	S	3.6	3.5	S	2.6	2.4	.0345	.0644	.0558	9.0	9.8	9.1	3.0	4.0	3.9	2.1	2.8	2.8
.0438	.0642	.0518	9.3	10.0	9.6	3.4	3.8	3.9	2.5	2.7	2.5	.0557	.0643	.0570	9.5	9.9	9.5	3.7	4.0	4.0	2.7	3.0	2.9
.0338	.0558	S	9.1	9.9	S	3.1	3.8	S	2.1	2.5	S	.0383	.0536	.0377	8.3	9.8	8.9	3.5	3.7	3.2	2.2	2.5	2.3
S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

TABLE I.—*Development of kernels of Manchuria barley from flowering to maturity in normal and clipped spikes at St. Paul, Minn., 1915*—Con.

JULY 27

Normal spikes.												Clipped spikes.											
Weight.			Length.			Lateral diameter.			Dorsoventral diameter.			Weight.			Length.			Lateral diameter.			Dorsoventral diameter.		
Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.
Gm.	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Gm.*	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
0.0395	S	0.0410	8.7	S	8.3	3.4	S	3.5	2.3	S	2.4	0.0389	0.0486	0.0400	7.8	8.0	7.8	3.4	3.7	3.4	2.4	2.6	2.5
.0485	0.0643	.0464	8.1	9.3	8.7	3.8	4.1	3.6	2.7	3.1	2.8	.0458	.0584	S	8.0	8.5	S	3.8	4.0	4.0	2.5	3.1	S
.0513	.0640	.0523	9.2	9.0	8.9	3.8	4.1	3.7	2.7	3.0	2.8	.0483	.0643	.0502	8.4	9.1	8.5	3.8	3.9	3.7	2.5	3.1	2.6
.0506	.0693	.0532	9.1	9.9	9.1	3.7	4.2	3.5	2.6	3.0	2.6	.0452	.0688	.0535	8.5	9.3	8.7	3.6	4.2	3.7	2.5	3.2	2.7
.0527	.0717	.0554	9.2	10.1	9.0	3.6	4.0	3.6	2.7	3.1	2.8	.0442	.0703	.0576	8.6	9.6	9.2	3.5	4.0	3.9	2.5	3.1	2.9
.0568	.0758	.0639	9.8	10.3	9.4	3.8	4.1	4.1	2.7	3.0	3.0	.0366	Dec.	.0359	9.2	Dec.	8.8	3.2	......	3.0	2.4	......	2.3
.0551	.0735	.0587	10.5	10.8	9.2	3.7	4.1	3.8	2.7	2.9	2.8	.0528	.0747	.0477	9.1	10.2	8.9	3.6	4.3	3.7	2.6	3.1	2.5
.0569	.0735	.0601	9.3	10.6	9.6	3.7	4.1	4.0	2.6	3.2	2.7	.0514	.0753	.0578	9.3	10.2	9.0	3.8	4.0	4.0	2.3	3.2	2.7
.0432	.0458	.0341	9.1	9.5	7.8	3.5	3.7	3.3	2.2	2.2	2.1	.0484	.0568	.0426	8.9	9.5	8.5	3.6	3.8	3.5	2.4	2.6	2.3
S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

JULY 28

0.0324	0.0460	S	7.9	8.2	S	3.2	3.7	S	2.3	2.7	S	S	S	S	S	S	S	S	S	S	S	S	......
.0483	.0600	0.0453	8.2	8.5	8.4	3.6	4.0	3.6	2.7	3.2	2.6	0.0359	0.0422	0.0284	8.4	8.7	8.1	3.2	3.3	3.2	2.2	2.4	2.1
.0500	.0503	.0501	8.2	9.0	8.5	3.8	3.7	3.7	2.6	2.6	2.7	.0314	.0486	.0297	8.7	9.0	8.7	3.0	3.5	3.2	2.1	2.7	2.0
.0558	.0668	.0519	8.5	9.2	8.0	3.8	4.1	3.9	2.7	3.1	2.7	.0430	.0473	.0393	8.7	9.0	8.4	3.6	3.7	3.4	2.6	2.6	2.4
.0597	.0726	.0560	8.9	9.7	8.8	4.0	4.1	3.8	3.0	3.0	2.8	.0439	.0600	.0408	9.0	9.3	8.8	3.4	3.8	3.3	2.3	2.8	2.3
.0622	.0727	.0581	9.0	10.1	9.4	4.0	4.1	3.8	2.7	3.0	2.8	.0428	.0399	Dec.	9.2	9.1	Dec.	3.4	3.3	......	2.3	2.2	......
.0574	.0746	.0342	8.8	9.8	8.0	3.7	4.2	3.2	2.8	3.1	2.2	.0526	.0615	.0492	9.1	9.8	8.8	3.5	3.8	3.5	2.7	2.8	2.5
.0422	.0719	.0425	8.6	10.1	9.0	3.3	4.0	3.6	2.3	3.0	2.6	.0458	.0635	.0494	8.9	10.3	9.1	3.5	3.8	3.6	2.4	2.8	2.4
.0417	.0337	S	8.5	8.8	S	3.3	3.0	S	2.3	2.0	S	.0390	.0539	.0212	9.1	10.0	8.3	3.4	3.7	2.7	2.0	2.6	1.6
S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

JULY 29

0.0374	0.0544	0.0387	8.1	8.7	8.0	3.4	3.8	3.3	2.4	3.0	2.5	S	0.0358	0.0243	S	8.3	7.8	S	3.1	2.8	S	2.4	1.9
S	.0604	.0477	S	8.7	8.6	S	4.0	3.6	S	3.0	2.7	0.0275	.0475	.0337	7.6	8.5	8.1	3.0	3.6	3.1	2.0	2.8	2.4
.0519	.0725	.0480	8.7	9.3	5.7	3.7	4.2	3.7	2.9	3.4	2.6	.0361	.0514	.0318	8.7	9.0	8.4	3.3	3.6	2.9	2.3	2.9	2.4
.0554	.0740	.0598	8.5	9.3	8.9	3.9	4.3	3.9	2.9	3.4	3.1	.0443	.0561	.0455	8.7	10.1	8.2	3.4	3.7	3.7	2.4	2.8	2.6
.0634	.0778	.0608	9.1	10.1	9.0	3.9	4.3	3.9	3.2	3.4	3.0	.0527	.0597	.0398	9.0	9.7	8.7	3.6	3.8	3.3	2.7	2.8	2.4
.0649	.0759	.0660	9.0	9.7	9.6	3.9	4.3	4.0	3.1	3.3	3.1	.0496	.0704	.0453	8.5	9.7	9.1	3.6	4.0	3.4	2.6	3.1	2.6
.0532	.0823	S	9.3	9.8	S	3.5	4.6	S	2.7	3.3	S	.0396	.0577	.0487	8.7	9.3	9.4	3.3	3.7	3.5	2.4	2.7	2.5
S	.0801	.0584	S	10.4	9.0	S	4.4	3.8	S	3.3	2.9	.0287	.0273	.0275	9.0	9.2	8.0	2.9	2.7	3.0	2.1	2.0	2.0
.0529	S	.0463	8.9	S	8.5	3.8	S	3.7	2.7	S	2.6	Dec.	.0421	S	Dec.	10.2	S	......	3.1	S	......	2.3	S
S	S	S	S	S	S	S	S	S	S	S	S	.0395	.0603	S	8.6	10.4	S	3.4	3.7	S	2.3	2.8	S
......	......	......	......	......	......	......	......	......	......	......	......	S	S	S	S	S	S	S	S	S	S	S	S

JULY 30

0.0283	0.0435	S	8.0	8.0	S	3.0	3.5	S	2.2	2.7	S	S	0.0305	0.0282	S	7.4	7.6	S	3.2	3.1	S	2.3	2.1
.0356	.0490	0.0320	8.1	9.0	8.5	3.3	3.7	3.0	2.3	2.7	2.2	0.0337	.0457	.0340	8.0	8.6	8.3	3.1	3.5	3.1	2.4	2.8	2.2
.0445	.0570	.0392	9.0	9.1	7.6	3.5	3.8	3.4	2.5	3.0	2.4	.0405	.0477	.0398	8.2	8.7	8.3	3.4	3.7	3.3	2.4	2.7	2.4
.0437	.0662	.0534	8.8	9.4	8.9	3.4	4.2	3.8	2.6	3.1	2.8	.0445	.0653	.0469	8.5	9.3	8.2	3.5	4.0	3.7	2.6	3.1	2.7
.0491	.0647	.0534	8.7	9.3	8.9	3.6	4.0	3.7	2.6	2.9	2.7	.0503	.0619	.0522	8.4	9.4	8.6	3.7	3.9	3.7	2.7	2.9	2.8
.0501	.0737	.0600	8.8	9.7	9.2	3.5	4.2	3.8	2.8	3.3	3.0	.0522	.0698	.0650	9.0	9.7	9.2	3.7	4.1	3.9	2.8	3.1	3.2
.0578	.0785	.0630	9.1	10.2	9.4	3.7	4.2	4.0	2.8	3.2	2.9	.0535	.0588	.0622	8.5	9.1	9.2	3.8	4.0	3.9	2.9	3.0	3.0
.0582	.0730	.0602	9.5	10.4	9.6	3.8	4.1	3.8	2.9	3.0	3.1	.0638	.0808	.0619	8.9	10.2	9.1	4.0	4.1	3.9	3.1	3.4	3.1
.0498	.0685	.0516	9.5	10.5	9.2	3.6	4.1	3.7	2.6	2.9	2.7	S	.0675	.0541	S	10.0	8.9	S	4.0	3.7	S	3.2	2.7
.0429	.0635	S	8.8	10.2	S	3.6	3.7	S	2.4	3.0	S	S	S	S	S	S	S	S	S	S	S	S	S
S	S	S	S	S	S	S	S	S	S	S	S	......	......	......	......	......	......	......	......	......	......	......	......

JULY 31

0.0386	0.0467	0.0341	8.1	8.8	7.9	3.4	3.5	3.2	2.5	2.7	2.4	S	0.0355	S	S	8.8	S	S	3.1	S	S	2.3	S
.0476	.0580	.0397	8.6	9.2	8.7	3.7	3.8	3.4	2.7	3.1	2.4	0.0163	.0462	0.0258	7.6	9.0	8.1	2.6	3.5	3.0	1.6	2.5	1.9
.0412	.0635	.0521	8.1	8.8	9.0	3.4	4.1	3.7	2.6	3.1	3.0	.0211	.0480	.0330	8.2	9.3	8.2	2.8	3.6	3.1	1.8	2.7	2.3
.0519	.0780	.0613	8.7	9.5	9.3	3.6	4.3	4.0	2.8	3.4	2.9	.0362	.0575	.0401	8.6	9.6	9.0	3.2	3.7	3.1	2.3	2.7	2.2
.0460	.0741	.0608	9.0	9.6	9.0	4.0	4.3	3.8	3.0	3.2	3.0	.0259	.0594	.0516	8.3	9.9	9.0	2.8	3.6	3.6	2.1	2.8	2.8
.0594	.0804	.0606	9.2	10.0	9.3	3.8	4.3	3.7	3.0	3.3	3.1	.0468	.0594	.0462	9.1	9.8	8.8	3.4	3.8	3.5	2.6	2.9	2.7
.0592	.0692	.0612	9.5	10.5	9.6	3.7	4.0	3.9	2.9	3.0	2.9	.0483	.0670	.0503	9.0	10.0	9.0	3.5	4.0	3.6	2.5	3.0	2.8
.0525	.0719	.0589	9.0	10.6	9.6	3.6	4.1	3.7	2.7	3.1	2.8	.0402	.0624	.0560	9.1	10.2	9.2	3.2	4.0	3.8	2.5	2.8	2.9
.0332	.0617	.0498	8.7	10.5	9.3	3.0	3.8	3.6	2.1	2.8	2.7	.0418	.0588	.0489	9.5	10.2	9.2	3.3	3.7	3.5	2.4	2.8	2.6
S	S	S	S	S	S	S	S	S	S	S	S	.0351	.0464	S	9.1	9.8	S	3.2	3.5	S	2.2	2.4	S
......	......	......	......	......	......	......	......	......	......	......	......	S	S	S	S	S	S	S	S	S	S	S	S

TABLE I.—*Development of kernels of Manchuria barley from flowering to maturity in normal and clipped spikes at St. Paul, Minn., 1915*—Con.

Normal spikes.												Clipped spikes.											
Weight.			Length.			Lateral diameter.			Dorsoventral diameter.			Weight.			Length.			Lateral diameter.			Dorsoventral diameter.		
Lateral kernel.	Central kernel.	Lateral kernel.	Lateral. kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.	Lateral ker. nel.	Central kernel.	Lateral kernel.	Lateral kernel.	Central kernel.	Lateral kernel.
AUGUST 2																							
Gm.	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Gm.*	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
S	0.0505	0.0350	S	8.8	8.0	S	3.6	3.2	S	2.9	2.5	S	S	S	S	S	S	S	S	S	S	S	S
0.0510	.0669	.0587	8.5	9.1	8.3	3.7	4.2	3.9	2.8	3.3	3.1	0.0375	0.0477	0.0357	8.6	8.7	8.6	3.3	3.7	3.2	2.5	2.9	2.4
.0543	.0686	.0590	8.5	9.1	8.9	3.8	4.1	3.7	3.0	3.3	3.1	.0409	S	.0382	8.6	S	8.4	3.5	S	3.4	2.4	S	2.5
.0477	.0755	.0626	8.3	9.6	8.9	3.4	4.5	4.0	2.7	3.3	3.1	.0556	.0627	.0448	8.8	9.8	8.8	3.7	4.0	3.5	3.0	3.0	2.5
.0681	.0857	.0636	9.2	10.2	9.4	4.2	4.5	4.0	3.2	3.5	3.1	.0589	.0626	.0465	9.0	9.8	8.6	3.9	3.8	3.5	2.9	3.0	2.7
.0700	.0883	.0691	9.1	10.2	9.3	4.1	4.4	4.0	3.3	3.4	3.1	.0595	.0625	.0544	9.0	9.7	8.8	3.9	4.0	3.7	2.9	2.9	2.8
.0612	.0831	.0653	9.7	9.8	9.5	3.9	4.3	4.0	3.0	3.3	3.1	.0454	.0855	.0690	8.8	9.9	9.6	3.4	4.4	4.1	2.6	3.5	3.1
.0578	.0845	.0577	8.9	10.6	9.0	3.8	4.2	3.7	2.9	3.4	2.9	.0750	.0794	.0673	9.5	10.2	9.6	4.3	4.2	4.0	3.3	3.3	3.3
.0629	.0708	.0606	9.0	10.1	9.2	3.8	4.1	3.9	3.0	3.0	3.3	.0686	.0846	.0739	9.6	10.6	9.6	4.2	4.4	4.2	3.1	3.3	3.2
S	S	S	S	S	S	S	S	S	S	S	S	.0712	.0892	.0742	9.6	10.5	9.6	4.1	4.5	4.3	3.2	3.4	3.3
......	......	......	......	......	......	......	......	......	......	......	......	.0623	.0337	.0626	9.5	10.5	9.6	3.8	2.9	4.0	2.7	2.2	2.9
......	......	......	......	......	......	......	......	......	......	......	......	S	S	S	S	S	S	S	S	S	S	S	S
AUGUST 4																							
0.0315	0.0611	0.0459	7.7	8.7	8.5	3.1	4.0	3.6	2.1	3.0	2.7	0.0190	0.0315	0.0212	7.8	8.6	7.6	2.8	3.1	2.5	1.6	2.3	1.9
.0516	.0647	.0486	8.4	9.3	7.8	3.8	4.0	3.7	2.9	3.1	2.8	.0289	.0347	.0308	8.2	8.8	8.2	3.0	3.2	3.2	2.0	2.3	2.1
.0549	.0706	.0528	8.6	9.2	8.7	3.8	4.2	3.9	2.9	3.3	2.8	.0274	.0408	.0346	8.8	8.8	8.4	3.1	3.5	3.4	2.1	2.3	2.3
.0515	.0705	.0580	8.9	9.8	9.0	3.8	4.2	3.9	2.7	3.2	3.0	.0372	.0463	Missing	9.0	9.2	......	3.2	3.7	......	2.3	2.5	......
.0643	.0776	.0409	9.1	9.5	8.8	4.0	4.3	3.4	3.0	3.4	2.4	.0349	.0455	.0402	9.0	9.3	8.9	3	3.4	3.3	2.3	2.6	2.3
.0622	.0756	.0417	9.2	10.2	9.3	4.0	4.4	3.4	2.9	3.2	2.4	.0371	.0313	.0386	9.1	9.6	9.4	3.2	3.1	3.1	2.3	2.2	2.5
.0656	.0850	.0540	9.2	10.4	9.1	4.0	4.4	3.8	3.1	3.4	2.7	S	.0463	.0425	S	10.0	9.3	S	3.4	3.5	S	2.3	2.5
.0650	.0815	.0597	9.3	10.5	9.0	4.1	4.4	4.0	3.1	3.3	2.8	.0261	.0431	.0454	8.5	10.3	9.5	3.0	3.4	3.5	2.0	2.3	2.3
S	.0705	.0464	S	10	8.8	S	4.0	3.5	S	3.1	2.6	.0345	.0442	.0311	9.4	9.8	9.4	3.1	3.4	2.8	2.2	2.3	1.9
S	S	S	S	S	S	S	S	S	S	S	S	.0155	.0273	.0176	7.8	9.4	7.9	2.6	2.8	2.6	1.4	1.7	1.6
......	......	......	......	......	......	......	......	......	......	......	......	S	S	S	S	S	S	S	S	S	S	S	S

AUGUST 5

0.0457	0.0620	0.0402	7.9	9.0	7.8	3.7	3.9	3.5	2.8	3.1	2.5	0.0298	0.0446	0.0317	8.1	8.9	7.9	3.0	3.4	3.1	2.3	2.8	2.2
.0550	.0713	.0477	8.6	9.0	8.2	3.8	4.3	3.5	3.0	3.5	2.8	.0310	.0490	.0355	7.8	8.7	7.9	3.2	3.7	3.2	2.3	2.9	2.4
.0596	.0777	.0581	8.8	9.6	8.0	3.8	4.4	3.8	3.1	3.4	3.0	.0344	.0572	.0392	8.5	9.3	8.4	3.2	3.9	3.2	2.3	2.9	2.5
.0636	.0800	.0664	9.0	10.2	8.8	3.9	4.2	3.8	3.1	3.3	3.2	.0410	.580	.0431	8.3	9.1	8.1	3.3	3.7	3.4	2.6	2.9	2.6
.0665	.0840	.0665	9.2	10	9.1	3.9	4.2	4.0	3.2	3.4	3.1	.0412	.0427	.0319	8.4	9.5	8.2	3.4	3.4	3.1	2.4	2.5	2.4
.0652	.0870	.0648	8.9	10.2	9.1	3.8	4.2	3.8	3.1	3.5	3.2	.0352	.0652	.0419	8.7	9.9	8.2	3.0	3.9	3.5	2.2	2.9	2.6
.0477	.0862	.0567	8.8	10.3	9.1	3.5	4.2	3.6	2.6	3.5	2.8	S	.0611	.0402	S	10.	8.9	S	3.7	3.4	S	2.8	2.3
.0567	.0685	S	9.1	10.5	S	3.7	4.0	S	2.9	2.9	S	S	S	S	S	S	S	S	S	S	S	S	S
S	S	S	S	S	S	S	S	S	S	S	S	.0512	.0772	.0618	8.7	10.2	9.2	3.7	4.1	3.8	2.7	3.2	2.8
......	......	......	......	......	......	......	......	......	......	......	......	S	S	S	S	S	S	S	S	S	S	S	S

AUGUST 6

0.0263	0.0343	S	7.6	9.0	S	2.8	3.2	S	2.2	2.5	S	0.0255	0.0358	0.0247	8.0	8.2	7.5	2.8	3.2	2.8	2.2	2.5	2.1
.0315	.0403	0.0309	8.1	8.6	7.9	3.0	3.5	3.1	2.3	2.7	2.4	.0257	.0343	.0195	7.9	9.0	7.6	2.8	3.2	2.6	2.0	2.3	1.8
.0398	.0452	.0382	8.3	8.6	8.2	3.3	3.6	3.3	2.5	2.8	2.5	.0302	.0478	.0331	8.0	9.1	7.8	3.0	3.4	3.0	2.3	2.7	2.3
.0416	.0556	.0380	8.7	9.5	8.3	3.4	3.8	3.2	2.6	2.9	2.6	.0376	.0516	.0357	8.4	9.4	8.3	3.2	3.5	3.2	2.4	2.8	2.4
.0440	.0606	.0425	8.6	9.7	8.8	3.5	3.8	3.4	2.5	3.0	2.5	.0297	.0515	.0421	8.3	9.2	8.2	2.9	3.3	3.4	2.3	2.8	2.5
.0482	.0583	.0481	9.0	10	8.4	3.6	3.7	3.5	2.6	2.9	2.8	.0423	.0682	.0417	8.4	9.7	9.0	3.2	3.7	3.3	2.7	3.0	2.5
.0479	S	.0426	8.8	S	8.6	3.6	S	3.4	2.5	S	2.6	.0426	.0659	.0594	8.8	9.9	8.8	3.3	3.8	3.7	2.5	2.9	2.7
.0402	.0537	S	9.1	9.7	S	3.2	3.4	S	2.4	2.6	S	.0393	.0435	.0548	8.7	9.6	9.0	3.1	3.2	3.7	2.3	2.5	2.8
.0354	.0454	.0275	8.5	9.7	7.8	3.0	3.3	2.8	2.1	2.5	1.9	.0352	.0670	.0384	8.4	9.8	8.5	3.1	3.9	3.2	2.1	2.9	2.2
S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

AUGUST 7

0.0298	0.0362	0.0287	8.0	7.8	7.7	3.0	3.3	3.3	2.4	2.5	2.3	0.0191	0.0328	0.0215	7.9	8.7	7.6	2.5	3.2	2.7	1.9	2.4	2.0
.0280	.0435	.0360	8.4	8.5	8.0	2.8	3.6	3.2	2.3	2.8	2.6	.0283	.0379	.0286	8.1	8.7	8.1	2.9	3.3	2.9	2.3	2.5	2.2
.0429	.0457	.0419	8.7	9.1	8.6	3.3	3.6	3.3	2.7	2.8	2.6	[a] Dis.	.0230	......	Dis.	9.0	Dis.	......	2.8	......	......	2.1	......
.0443	.0582	.0416	8.5	9.5	8.5	3.4	3.9	3.4	2.7	3.0	2.7	.0238	.0232	Dis.	8.2	8.9	Dis.	2.7	2.8	......	2.1	1.9	......
.0491	.0503	S	8.9	9.7	S	3.4	3.5	S	2.7	2.7	S	.0374	.0391	.0340	8.7	9.3	8.7	3.2	4.2	3.2	2.5	2.5	2.4
.0538	.0702	.0498	8.8	9.6	8.5	3.7	4.0	3.5	2.8	3.0	2.8	.0350	S	.0377	8.6	S	9.1	3.2	S	3.3	2.4	S	2.5
.0494	.0698	.0476	9.0	9.6	8.8	3.5	4.0	3.5	2.6	3.0	2.7	.0372	.0500	.0347	8.4	9.7	8.1	3.2	3.5	3.2	2.5	2.7	2.4
.0477	.0450	.0429	9.3	9.6	8.8	3.5	3.4	3.4	2.5	2.7	2.6	.0347	.0436	.0338	8.7	9.9	8.9	3.0	3.1	3.1	2.3	2.5	2.3
S	S	S	S	S	S	S	S	S	S	S	S	.0351	.0476	.0351	8.5	9.6	8.4	3.1	3.4	3.0	2.3	2.7	2.3
......	......	......	......	......	......	......	......	......	......	......	......	S	S	S	S	S	S	S	S	S	S	S	S

[a] Diseased.

The use of a single spike and the great change of climatic conditions from day to day in Minnesota resulted in a much less uniform trend to the results than was the case with the Hannchen barley previously reported.[1] A sample should consist of more than one spike; but, entirely aside from the smallness of the sample, Minnesota is not a desirable place to make a study of this kind. There are many cold, dark days in which little growth occurs, while frequent storms break the culms and cause lodging. The lodging was so bad during the latter part of the experiment that many of the culms started to decay near the base. The resultant irregularities are quite apparent in Table II, where the data presented in Table I are summarized.

TABLE II.—*Average wet weight, length, lateral diameter, and dorsoventral diameter of kernels from normal and clipped spikes of Manchuria barley at St. Paul, Minn., in 1915*

NORMAL SPIKES

Date.	Wet weight.				Length.				Lateral diameter.				Dorsoventral diameter.			
	Lateral kernel.	Central kernel.	Lateral kernel.	Average.	Lateral kernel.	Central kernel.	Lateral kernel.	Average.	Lateral kernel.	Central kernel.	Lateral kernel.	Average.	Lateral kernel.	Central kernel.	Lateral kernel.	Average.
	Mgm.	*Mgm.*	*Mgm.*	*Mgm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
July 1	0.9	1.2	0.9	1.0	1.9	2.1	1.8	1.9	0.7	0.7	0.7	0.7	.....	.....	.....	.....
2	1.1	1.7	1.2	1.3	2.0	2.3	2.0	2.1	.7	.8	.7	.7	.....	.....	.....	.....
3	1.3	1.8	1.2	1.4	2.0	2.1	1.9	2.0	.7	.8	.7	.7	.....	.....	.....	.....
5	1.7	2.7	1.8	2.1	2.2	2.5	2.2	2.3	.8	1.0	.9	.9	0.6	0.8	0.6	0.7
7	6.3	10.2	5.7	7.4	4.2	5.2	3.8	4.4	1.5	1.7	1.4	1.5	1.0	1.1	1.0	1.0
8	6.7	8.2	5.9	6.9	4.3	4.6	4.0	4.3	1.5	1.6	1.5	1.5	1.0	1.1	1.0	1.0
9	7.0	9.3	7.1	7.8	4.3	5.0	4.4	4.6	1.6	1.7	1.7	1.7	1.1	1.2	1.1	1.1
10	10.7	14.7	10.3	11.9	5.9	7.2	5.8	6.3	1.8	2.1	1.8	1.9	1.2	1.3	1.1	1.2
11	17.3	20.1	16.2	17.9	8.2	8.5	7.8	8.2	2.3	2.2	2.2	2.2	1.5	1.5	1.5	1.5
12	21.1	27.0	19.3	22.5	8.9	9.7	8.6	9.1	2.3	2.6	2.2	2.4	1.6	1.7	1.5	1.6
13	22.7	29.9	23.8	25.5	8.9	9.7	8.9	9.2	2.4	2.7	2.5	2.5	1.7	1.8	1.7	1.7
14	31.1	40.7	33.3	35.0	9.4	10.3	9.5	9.7	2.9	3.1	2.9	3.0	2.0	2.2	2.1	2.1
15	41.1	49.3	38.1	42.8	9.5	10.2	9.5	9.7	3.3	3.5	3.2	3.3	2.2	2.3	2.1	2.2
16	39.2	48.0	36.5	41.2	9.6	10.0	9.7	9.8	3.2	3.6	3.2	3.3	2.2	2.4	2.1	2.2
17	39.2	51.1	40.6	43.6	9.4	10.4	9.6	9.8	3.4	3.6	3.4	3.5	2.2	2.5	2.3	2.3
19	44.3	58.5	42.4	48.4	9.4	10.1	9.5	9.7	3.5	3.8	3.4	3.6	2.4	2.8	2.3	2.5
20	45.5	56.6	44.1	48.7	9.4	10.0	9.3	9.6	3.5	3.7	3.4	3.5	2.4	2.6	2.3	2.4
21	41.4	54.5	42.0	46.0	9.3	10.0	9.3	9.5	3.4	3.8	3.5	3.6	2.4	2.7	2.4	2.5
22	48.9	61.3	48.8	53.0	9.4	10.1	9.3	9.6	3.8	4.0	3.7	3.8	2.6	2.9	2.6	2.7
23	51.8	60.2	50.5	54.2	9.3	9.8	9.3	9.5	3.8	3.9	3.7	3.8	2.6	2.8	2.5	2.6
24	44.0	54.2	45.6	47.9	9.4	10.0	9.3	9.6	3.5	3.8	3.6	3.6	2.4	2.7	2.4	2.5
26	41.9	59.3	51.1	50.8	8.9	9.7	9.1	9.2	3.4	3.8	3.7	3.6	2.3	2.7	2.6	2.5
27	50.5	67.3	51.7	56.5	9.2	9.9	8.9	9.3	3.7	4.1	3.7	3.8	2.6	2.9	2.7	2.7
28	50.0	61.0	48.3	53.1	8.5	9.3	8.6	8.8	3.6	3.9	3.7	3.7	2.6	2.9	2.6	2.7
29	54.2	72.2	53.2	59.9	8.8	9.5	8.8	9.0	3.7	4.2	3.7	3.9	2.8	3.3	2.8	3.0
30	46.0	63.8	51.6	53.8	8.8	9.6	8.9	9.1	3.5	4.0	3.7	3.7	2.6	3.0	2.7	2.8
31	49.7	67.1	53.2	56.6	8.8	9.7	9.1	9.2	3.6	4.0	3.7	3.8	2.7	3.1	2.8	2.9
Aug. 2	59.2	74.9	59.1	64.4	8.9	9.7	8.9	9.2	3.8	4.2	3.8	3.9	3.0	3.3	3.0	3.1
4	55.8	73.0	49.8	59.5	8.8	9.7	8.8	9.1	3.8	4.2	3.7	3.9	2.8	3.2	2.7	2.9
5	57.5	77.1	57.2	63.9	8.8	9.9	8.7	9.1	3.8	4.2	3.7	3.9	3.0	3.3	2.9	3.5
6	39.4	49.2	38.3	42.3	8.5	9.4	8.3	8.7	3.3	3.5	3.2	3.3	2.4	2.7	2.5	2.5
7	43.1	52.4	41.2	45.6	8.7	9.2	8.4	8.8	3.3	3.7	3.4	3.5	2.6	2.8	2.6	2.7

[1] HARLAN, Harry V., OP. CIT.

TABLE II.—*Average net weight, length, lateral diameter, and dorsoventral diameter of kernels from normal and clipped spikes of Manchuria barley at St. Paul, Minn., in 1915*—Continued

CLIPPED SPIKES

Date.	Wet weight.				Length.				Lateral diameter.				Dorsoventral diameter.			
	Lateral kernel.	Central kernel.	Lateral kernel.	Average.	Lateral kernel.	Central kernel.	Lateral kernel.	Average.	Lateral kernel.	Central kernel.	Lateral kernel.	Average.	Lateral kernel.	Central kernel.	Lateral kernel.	Average.
	Mgm.	*Mgm.*	*Mgm.*	*Mgm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
July 2	1.5	2.3	1.5	1.8	2.2	2.5	2.3	2.3	0.8	0.9	0.7	0.8	.....	.....	.....	.....
3	1.4	2.1	1.5	1.7	2.1	2.4	2.1	2.2	.7	.8	.7	.7	.....	.....	.....	.....
5	2.1	3.2	2.0	2.4	2.4	2.6	2.3	2.4	1.1	1.2	1.1	1.1	0.8	0.8	0.8	0.8
7	5.6	7.9	5.6	6.4	3.8	4.5	3.8	4.0	1.4	1.6	1.4	1.5	1.0	1.1	1.0	1.0
8	4.0	5.6	3.9	4.5	3.3	3.7	3.3	3.4	1.3	1.4	1.3	1.3	.9	1.0	.9	.9
9	8.5	11.4	7.8	9.2	5.2	6.1	4.8	5.4	1.6	1.8	1.6	1.7	1.0	1.2	1.0	1.1
10	10.8	15.8	10.1	12.2	6.4	7.7	6.2	6.8	1.8	2.3	1.8	2.0	1.2	1.4	1.2	1.3
11	14.8	18.4	13.6	15.6	7.3	8.0	7.0	7.4	2.0	2.2	1.9	2.0	1.4	1.5	1.3	1.4
12	20.2	24.5	20.8	21.8	8.3	9.0	8.5	8.6	2.3	2.5	2.3	2.4	1.6	1.7	1.6	1.6
13	28.3	38.6	28.6	31.8	9.1	10.0	9.1	9.4	2.7	3.1	2.8	2.9	1.8	2.1	1.8	1.9
14	29.0	39.5	29.5	32.7	9.0	10.2	8.9	9.4	2.8	3.3	2.9	3.0	1.9	2.2	2.0	2.0
15	32.4	38.4	35.8	35.5	9.1	9.6	9.3	9.3	3.0	3.2	3.1	3.1	1.9	2.1	2.1	2.0
16	35.6	43.2	35.9	38.2	9.3	10.0	9.3	9.5	3.2	3.4	3.2	3.3	2.0	2.3	2.0	2.1
17	39.5	53.3	40.7	44.5	9.3	10.3	9.3	9.6	3.4	3.7	3.2	3.4	2.4	2.6	2.2	2.4
19	39.5	50.7	39.7	43.3	9.2	9.8	9.4	9.5	3.4	3.7	3.5	3.5	2.3	2.5	2.3	2.4
20	35.8	49.4	42.5	42.6	8.6	9.3	8.8	8.9	3.3	3.7	3.5	3.5	2.1	2.5	2.3	2.3
21	40.2	52.7	42.2	45.0	8.8	9.7	9.1	9.2	3.5	3.8	3.6	3.6	2.3	2.6	2.4	2.4
22	56.3	62.7	53.5	57.5	9.4	9.7	9.2	9.4	3.8	4.0	3.8	3.9	2.9	2.9	2.8	2.9
23	41.0	55.5	35.9	44.1	8.9	9.7	8.5	9.0	3.4	3.8	3.3	3.5	2.3	2.6	2.3	2.4
24	45.2	57.2	42.3	48.2	8.9	9.7	8.9	9.2	3.6	3.8	3.5	3.6	2.5	2.8	2.5	2.6
26	40.8	56.8	43.9	47.2	8.8	9.5	8.8	9.0	3.5	3.7	3.5	3.6	2.3	2.6	2.5	2.5
27	45.7	64.7	48.2	52.9	8.6	9.3	8.7	8.9	3.6	4.0	3.7	3.8	2.5	3.0	2.6	2.7
28	41.8	52.1	36.9	43.6	8.9	9.4	8.6	9.0	3.4	3.6	3.3	3.4	2.3	2.6	2.2	2.4
29	39.8	50.8	37.1	42.6	8.6	9.4	8.5	8.8	3.3	3.5	3.2	3.3	2.4	2.7	2.4	2.5
30	48.4	58.7	49.4	52.2	8.5	9.2	8.6	8.8	3.6	3.8	3.6	3.7	2.7	2.9	2.7	2.8
31	34.6	54.1	44.0	44.2	8.7	9.7	8.8	9.1	3.1	3.7	3.4	3.4	2.2	2.7	2.5	2.5
Aug. 2	57.5	67.5	56.7	60.6	9.1	10.0	9.1	9.4	3.8	4.0	3.8	3.9	2.9	3.1	2.9	3.0
4	29.0	39.1	33.6	33.9	8.6	9.4	8.7	8.9	3.0	3.3	3.1	3.1	2.0	2.3	2.2	2.2
5	37.7	56.9	40.7	45.1	8.4	9.5	8.4	8.8	3.3	3.7	3.3	3.4	2.4	2.9	2.5	2.6
6	34.2	51.7	38.8	41.6	8.3	9.3	8.3	8.6	3.0	3.5	3.2	3.2	2.3	2.7	2.4	2.5
7	31.3	37.2	32.2	33.6	8.4	9.2	8.4	8.7	3.0	3.3	3.1	3.1	2.3	2.4	2.3	2.3

In both the tables and the figures it is apparent that fertilization did not occur until about July 5; therefore, the measurements and weights before that date are of the ovary. Six-rowed barleys do not flower so uniformly as 2-rowed barleys. The central florets flower before the lateral ones. For this reason the curve of growth is less abrupt at the beginning than is the case with the 2-rowed varieties. Even with the prolonged period of flowering the length increases very rapidly after fertilization, as may be seen in figure 1.

The effect of the clipping is evident in both figure 1 and figure 2. Although there is little difference in length near maturity, the lateral diameters and the dorsoventral diameters of the kernels from clipped spikes are noticeably smaller than those of normal spikes. The difference is even more conspicuous in the wet weights per kernel. The question of mechanical injury from clipping is answered by a study of the growth by days. There is no such injury. For two weeks after clipping, the kernels in the clipped spikes develop as rapidly in size and weight as do those in

normal spikes. The graphs of wet weights per kernel coincide essentially until the fourteenth day after the experiment started. If there were a mechanical injury it would probably most seriously affect the kernel immediately after the injury.

After the fourteenth day the kernels in the normal spikes increase more rapidly in weight and size than do those in the clipped spikes. On only two days after July 14 do the clipped spikes exceed the normal ones, and these excesses are unquestionably due to the error of sampling which comes from the use of a single spike for this purpose.

The difference in rate of development begins to be noticeable about the time that the growth in length is completed. This coincides roughly with the beginning of the period of rapid starch infiltration. Whether

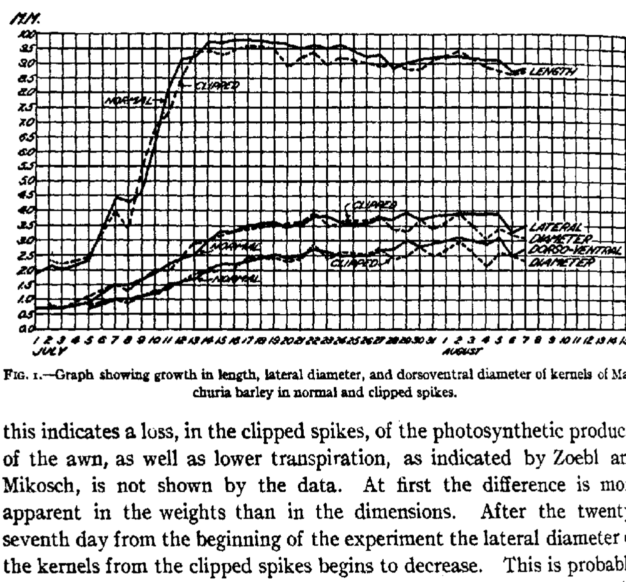

FIG. 1.—Graph showing growth in length, lateral diameter, and dorsoventral diameter of kernels of Manchuria barley in normal and clipped spikes.

this indicates a loss, in the clipped spikes, of the photosynthetic products of the awn, as well as lower transpiration, as indicated by Zoebl and Mikosch, is not shown by the data. At first the difference is more apparent in the weights than in the dimensions. After the twenty-seventh day from the beginning of the experiment the lateral diameter of the kernels from the clipped spikes begins to decrease. This is probably due to the rate of loss of water in maturation, which here exceeds the rate of deposit of dry matter. In the normal spikes the two changes about balance each other so far as their effect on the lateral diameter is concerned. The dorsoventral diameter continues to increase until full maturity in the normal spikes, while it is slightly less than maintained by the clipped spikes in the latter days. At the very last the kernels in the clipped spikes ripen faster than those in the normal spikes. This is apparent in both figure 2 and figure 3.

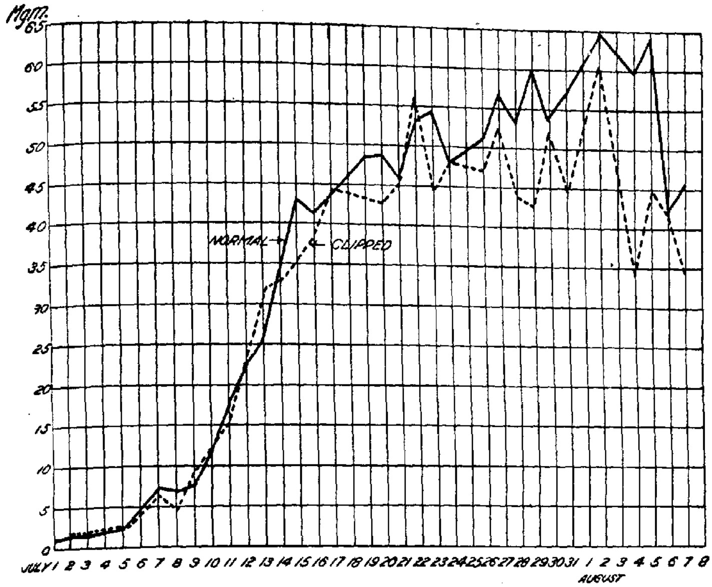

FIG. 2.—Graph showing wet weight of kernels of Manchuria barley from normal and clipped spikes.

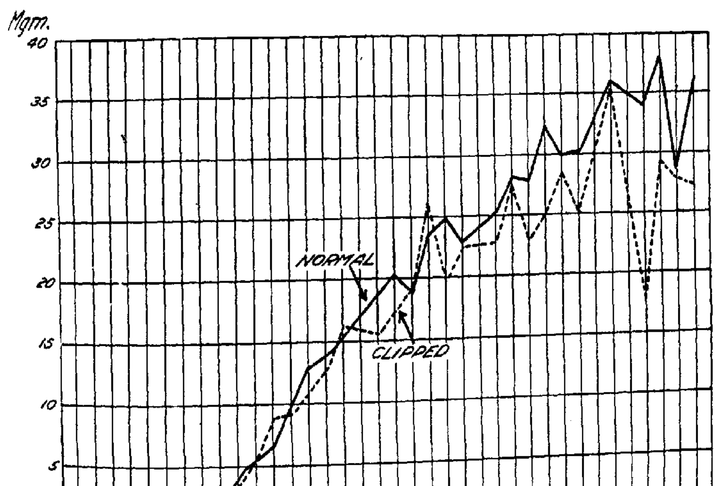

FIG. 3.—Graph showing dry matter in kernels of Manchuria barley from normal and clipped spikes.

The nitrogen, ash, and water were determined in all samples. Inasmuch as the glumes were removed, the difference between the total of these substances and the dry weight would approximate the sum of the carbohydrates and fats. This calculation has not been made. Its trend would be similar to that of the dry weight. The results of the analyses

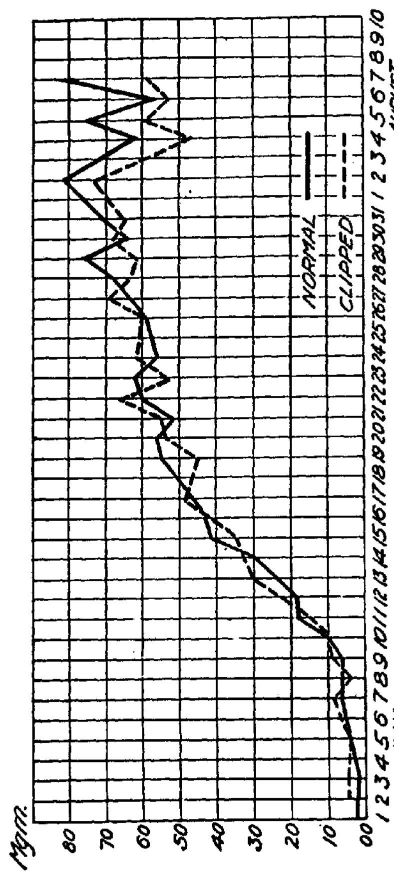

Fig. 4.—Graph showing total ash in kernels of Manchuria barley from normal and clipped spikes.

are given in Table III. The cause of the addition or loss of each substance determined is evident in the tables. Comparisons, however, are much more easily made in figures 3, 4, 5, and 6.

The graph of the dry weight is quite similar to that of the wet weight. In each case there is a marked reduction of the rate of growth of the kernels from clipped spikes in the latter half of the period of growth.

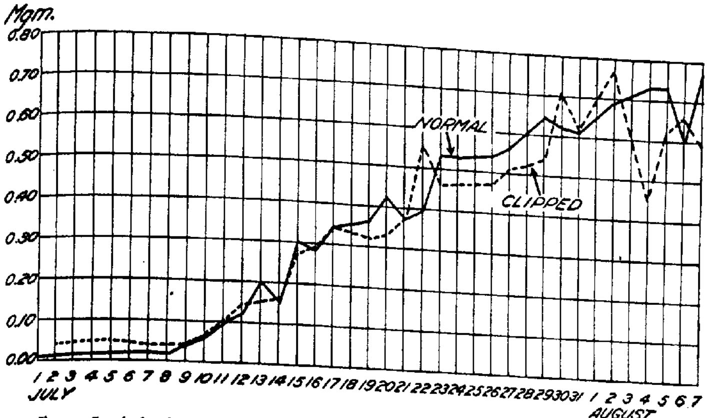

FIG. 5.—Graph showing total nitrogen in kernels of Manchuria barley from normal and clipped spikes.

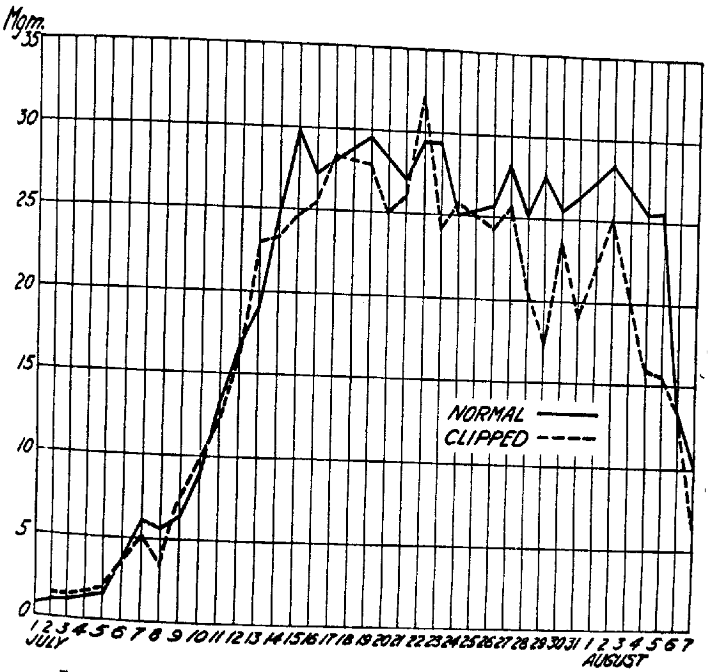

FIG. 6.—Graph showing water in kernels of Manchuria barley from normal and clipped spikes.

TABLE III.—*Average percentage and weight per kernel of dry matter, water, nitrogen, and ash in kernels from normal and clipped spikes of Manchuria barley at St. Paul, Minn., in 1915*

NORMAL SPIKES

Date.		Dry matter.	Water.	Nitrogen.	Ash.	Wet weight per kernel.	Dry Weight per kernel.	Water per kernel.	Nitrogen per kernel.	Ash per kernel.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Mgm.*	*Mgm.*	*Mgm.*	*Mgm.*	*Mgm.*
July	1	22.88	77.12	5.93	17.02	1.0	0.2	0.8	0.01	0.03
	2	22.82	77.18	....	....	1.3	.3	1.0	....	....
	3	21.43	78.57	....	7.33	1.4	.3	1.1	....	.02
	5	21.88	78.12	....	8.93	2.1	.5	1.6	....	.04
	7	18.12	81.88	1.51	5.40	7.4	1.3	6.1	.02	.07
	8	19.08	80.92	1.31	5.60	6.9	1.3	5.6	.02	.07
	9	18.36	81.64	2.80	5.07	7.8	1.4	6.4	.04	.07
	10	19.27	80.73	2.70	4.37	11.9	2.3	9.6	.06	.10
	11	22.79	77.21	2.32	4.24	17.9	4.1	13.8	.10	.17
	12	24.16	75.84	2.28	3.38	22.5	5.4	17.1	.12	.18
	13	25.99	74.01	3.10	3.45	25.5	6.6	18.9	.20	.23
	14	28.58	71.42	1.54	2.94	35.0	10.0	25.0	.15	.29
	15	30.15	69.85	2.30	3.15	42.8	12.9	29.9	.30	.41
	16	33.68	66.32	2.05	3.11	41.2	13.9	27.3	.28	.43
	17	35.49	64.51	2.22	3.06	43.6	15.5	28.1	.34	.47
	19	38.87	61.13	1.92	2.90	48.4	18.8	29.6	.36	.55
	20	41.61	58.39	2.08	2.76	48.7	20.3	28.4	.42	.56
	21	40.97	59.03	1.96	2.79	46.0	18.8	27.2	.37	.52
	22	44.62	55.38	1.65	2.55	53.0	23.6	29.4	.39	.60
	23	45.73	54.27	2.15	2.48	54.2	24.8	29.4	.53	.62
	24	47.78	52.22	2.33	2.46	47.9	22.9	25.0	.53	.56
	26	49.48	50.52	2.14	2.36	50.8	25.1	25.7	.54	.59
	27	49.76	50.24	1.98	2.25	56.5	28.1	28.4	.56	.63
	28	52.23	47.77	2.16	2.46	53.1	27.7	25.4	.60	.68
	29	53.75	46.25	1.99	2.36	59.9	32.2	27.7	.64	.76
	30	52.47	47.53	2.19	2.32	53.8	28.2	25.6	.62	.65
	31	53.15	46.85	2.01	2.37	56.6	30.1	26.5	.61	.71
Aug.	2	55.89	44.11	1.91	2.24	64.4	36.0	28.4	.69	.81
	4	56.92	43.08	2.14	1.81	59.5	33.9	25.6	.73	.61
	5	59.83	40.17	1.91	1.96	63.9	38.2	25.7	.73	.75
	6	67.89	32.11	2.10	2.01	42.3	28.7	13.6	.50	.58
	7	77.90	22.10	2.16	2.27	45.6	35.5	10.1	.77	.81

CLIPPED SPIKES

Date.		Dry matter.	Water.	Nitrogen.	Ash.	Wet weight per kernel.	Dry Weight per kernel.	Water per kernel.	Nitrogen per kernel.	Ash per kernel.
July	2	21.13	78.87	9.70	11.76	1.8	0.4	1.4	0.04	0.05
	3	22.82	77.18	....	12.22	1.7	.4	1.3	....	.05
	5	19.91	80.09	9.16	8.46	2.4	.5	1.9	.05	.04
	7	16.68	83.32	3.61	7.09	6.4	1.1	5.3	.04	.08
	8	17.40	82.60	....	6.53	4.5	.8	3.7	....	.05
	9	17.51	82.49	2.68	5.55	9.2	1.6	7.6	.04	.09
	10	19.11	80.89	2.79	4.30	12.2	2.3	9.9	.06	.10
	11	21.04	78.96	3.02	4.44	15.6	3.3	12.3	.10	.15
	12	24.89	75.11	2.57	3.80	21.8	5.4	16.4	.14	.21
	13	27.48	72.52	1.77	3.44	31.8	8.7	23.1	.15	.30
	14	28.41	71.59	1.69	3.48	32.7	9.3	23.4	.16	.32
	15	30.48	69.52	2.46	3.12	35.5	10.8	24.7	.27	.34
	16	33.61	66.39	2.23	3.19	38.2	12.8	25.4	.29	.41
	17	36.26	63.74	2.14	2.98	44.5	16.1	28.4	.34	.48
	19	35.64	64.36	2.05	2.89	43.3	15.4	27.9	.32	.45
	20	41.10	58.90	1.90	3.01	42.6	17.5	25.1	.33	.53
	21	42.30	57.70	1.95	2.83	45.0	19.0	26.0	.37	.54
	22	44.93	55.07	2.16	2.50	57.5	25.8	31.7	.56	.65
	23	44.77	55.23	2.33	2.62	44.1	19.7	24.4	.46	.52
	24	46.94	53.06	2.04	2.70	48.2	22.6	25.6	.46	.61

TABLE III.—*Average percentage and weight per kernel of dry matter, water, nitrogen, and ash in kernels from normal and clipped spikes of Manchuria barley at St. Paul, Minn., in 1915*—Continued

CLIPPED SPIKES

Date.		Dry matter.	Water.	Nitrogen.	Ash.	Wet weight per kernel.	Dry Weight per kernel.	Water per kernel.	Nitrogen per kernel.	Ash per kernel.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Mgm.*	*Mgm.*	*Mgm.*	*Mgm.*	*Mgm.*
July	26	48.61	51.39	2.04	2.60	47.2	22.9	24.3	0.47	0.60
	27	51.70	48.30	1.88	2.48	52.9	27.3	25.6	.51	.68
	28	52.60	47.40	2.27	2.76	43.6	22.9	20.7	.52	.63
	29	58.56	41.44	2.17	2.48	42.6	24.9	17.7	.54	.62
	30	54.39	45.61	2.51	2.38	52.2	28.4	23.8	.71	.68
	31	56.49	43.51	2.46	2.59	44.2	25.0	19.2	.62	.65
Aug.	2	58.30	41.70	2.17	2.07	60.6	35.3	25.3	.77	.73
	4	52.44	47.56	2.51	2.64	33.9	17.8	16.1	.45	.47
	5	64.99	35.01	2.11	2.02	45.1	29.3	15.8	.62	.59
	6	66.90	33.10	2.36	1.90	41.6	27.8	13.8	.66	.53
	7	81.18	18.82	2.15	2.12	33.6	27.3	6.3	.59	.58

The deposition of ash, on the other hand, is maintained in the kernels of clipped spikes for a much longer period. It is only in the final days of maturation that the total ash per kernel of the normal spikes exceeds that of the kernels of the clipped spikes. In Table III it will be seen that in percentage of ash the case is reversed. The kernels of the clipped spike have an appreciably higher percentage of ash. That the total is higher in the kernels of normal spikes is due to the greater weight of those kernels. In the experiment with Hannchen barley at Aberdeen several other determinations of ash were made, and a discussion of the significance of the ash content is better made after the results from that variety have been presented.

The nitrogen content per kernel is shown graphically in figure 5. During more than half the period of growth there is little difference in the rate of the deposit of nitrogenous materials in the spikes. From July 23 to July 29 there is apparently a more active deposit in the normal spikes. The graphs become confused as the kernels ripen. As a whole, there is not much difference between the two. As there is a definite difference in the dry weight, the deposit of carbohydrates must be decidedly greater in the normal spikes during the last half of the growing period.

The water per kernel is a good index of development. In normal development the water rapidly increases after fertilization and quickly attains its maximum. It then remains stabilized, or nearly so, as long as growth is efficiently maintained. When growth is checked or maturation begins, the water content drops slowly until complete ripeness occurs. After complete ripeness it drops still more rapidly for two or three days. It will be seen in figure 6 that the water content of the kernels from clipped spikes is about equal to that of the kernels from normal spikes

until July 25. After that date the kernels from clipped spikes exhibit a rapid loss of water which becomes accelerated about August 2.

In general, the differences in the development of the kernels from normal and clipped spikes are largely evident in the tables and figures. Certain observations and deductions seem justified. The discussion of the significance of the results at Minnesota, however, has been placed with that of results at Aberdeen, Idaho.

TABLE IV.—*Growth of kernels of Hannchen barley in awned and clipped spikes at Aberdeen, Idaho, in 1916*

Normal spikes.								Clipped spikes.							
Weight.		Length.		Lateral diameter.		Dorso-ventral diameter.		Weight.		Length.		Lateral diameter.		Dorso-ventral diameter.	
A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B	A.	B.
Gm.	Gm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Gm.	Gm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.
JULY 8															
0.0007	0.0007	2.4	1.9	......	0.6	......	......	......	......	......	......	......	......	......	......
.0011	.0010	2.2	1.8	0.8	.9	......	......	......	......	......	......	......	......	......	......
.0012	.0012	2.3	2.3	.6	1.0	......	......	......	......	......	......	......	......	......	......
.0012	.0013	2.3	2.0	.7	.9	......	......	......	......	......	......	......	......	......	......
.0013	.0017	2.4	2.2	.9	1.1	......	......	......	......	......	......	......	......	......	......
.0014	.0017	2.1	2.4	.8	1.1	......	......	......	......	......	......	......	......	......	......
.0014	.0017	2.3	2.2	.8	1.0	......	......	......	......	......	......	......	......	......	......
.0014	.0017	2.5	2.1	.8	1.0	......	......	......	......	......	......	......	......	......	......
.0017	.0017	2.3	2.4	.9	1.0	......	......	......	......	......	......	......	......	......	......
.0017	.0017	2.3	2.0	1.1	1.2	......	......	......	......	......	......	......	......	......	......
.0013	.0017	2.4	2.5	.9	1.0	......	......	......	......	......	......	......	......	......	......
.0011	.0014	2.2	2.3	.8	1.0	......	......	......	......	......	......	......	......	......	......
.0011	.0012	2.4	2.4	.6	1.0	......	......	......	......	......	......	......	......	......	......
.0011	.0009	2.2	2.1	.7	.8	......	......	......	......	......	......	......	......	......	......
.0008	.0008	1.9	1.8	.6	.7	......	......	......	......	......	......	......	......	......	......
JULY 10															
0.0009	0.0019	2.1	2.6	0.7	1.2	0.5	0.7	0.0015	0.0015	2.2	2.4	0.9	0.7	0.7	0.7
.0025	.0030	2.5	2.4	1.2	1.3	.9	1.0	.0026	.0027	2.7	2.9	1.2	1.2	.8	.7
.0031	.0039	2.7	3.4	1.4	1.5	1.0	1.0	.0033	.0032	2.6	2.7	1.4	1.2	1.0	.8
.0039	.0045	3.1	3.5	1.5	1.6	1.0	1.0	.0035	.0035	2.8	3.3	1.4	1.4	1.0	.8
.0041	.0047	3.3	3.5	1.4	1.5	1.0	1.0	.0037	.0038	3.2	3.2	1.3	1.4	1.0	.9
.0048	.0047	3.7	3.7	1.4	1.4	1.0	1.1	.0043	.0043	3.4	3.5	1.5	1.3	.9	.9
.0049	.0051	3.7	4.0	1.6	1.5	1.1	1.0	.0047	.0042	3.4	3.4	1.5	1.4	1.0	1.0
.0059	.0053	4.3	4.5	1.5	1.4	1.0	1.0	.0052	.0047	3.7	3.7	1.4	1.4	1.0	.9
.0058	.0054	4.2	4.2	1.5	1.5	1.1	1.0	.0049	.0044	3.5	3.5	1.4	1.5	1.0	.9
.0052	.0054	3.9	4.2	1.4	1.5	1.0	1.0	.0048	.0044	4.2	3.7	1.4	1.4	.8	.9
.0048	.0047	4.0	3.8	1.5	1.4	1.0	.9	.0045	.0041	3.7	3.4	1.3	1.4	1.0	1.0
.0045	.0039	4.1	3.9	1.4	1.5	1.0	.8	.0036	.0035	3.0	2.8	1.2	1.3	1.0	.7
.0034	.0037	3.3	3.6	1.4	1.3	.9	1.0	.0032	.0032	3.1	3.1	1.4	1.4	.9	.9
.0019	.0025	3.3	2.8	1.1	1.3	.8	.8	.0017	.0025	2.2	2.8	1.0	1.2	.6	.9
......	.0017	......	1.8	......	1.0	......	.7	......	.0021	......	2.8	......	1.1	......	.7
......	......	......	......	......	......	......	......	......	.0015	......	1.9	......	1.1	......	.6
JULY 11															
0.0026	0.0045	2.6	3.8	1.4	1.5	0.8	0.9	0.0038	0.0014	3.4	1.8	1.4	0.8	0.9	0.6
.0048	.0068	4.1	4.8	1.4	1.7	1.0	1.0	.0051	.0042	4.2	3.7	1.4	1.6	1.0	.9
.0062	.0074	4.6	5.2	1.5	1.5	1.0	.9	.0060	.0055	4.6	4.1	1.6	1.6	1.0	.9
.0069	.0081	5.1	5.7	1.6	1.6	1.2	1.0	.0073	.0063	5.3	4.9	1.5	1.5	.8	1.0
.0073	.0084	5.4	5.8	1.5	1.7	1.1	1.0	.0077	.0076	5.6	5.5	1.7	1.6	1.0	1.0
.0075	.0086	5.4	5.7	1.7	1.6	1.1	1.0	.0078	.0081	5.5	5.4	1.8	1.6	1.0	1.0
.0081	.0094	5.8	6.5	1.7	1.7	1.0	1.0	.0081	.0080	6.3	5.6	1.6	1.6	1.0	1.0
.0084	.0094	5.8	6.4	1.6	1.7	1.1	1.1	.0084	.0082	6.1	6.1	1.7	1.6	1.0	1.0
.0079	.0089	5.8	6.4	1.7	1.7	1.0	1.0	.0083	.0082	6.1	6.2	1.6	1.6	1.0	1.0
.0074	.0087	5.8	6.4	1.6	1.7	.9	1.0	.0083	.0082	6.5	5.9	1.6	1.7	1.0	1.0
.0068	.0084	5.1	6.4	1.6	1.8	.9	1.0	.0074	.0079	5.9	5.9	1.6	1.5	1.0	.9
.0058	.0074	4.4	5.7	1.5	1.6	1.0	1.0	.0069	.0071	5.7	5.5	1.5	1.5	1.0	1.0
.0042	.0066	4.0	5.2	1.5	1.6	.9	1.0	.0054	.0057	5.0	4.5	1.4	1.4	.9	1.0
.0032	.0055	3.1	4.9	1.4	1.4	.9	1.0	.0041	.0048	4.1	4.5	1.4	1.3	.8	.9
......	.0039	......	3.7	......	1.4	......	.9	......	.0036	......	3.7	......	1.3	......	.9

TABLE IV.—*Growth of kernels of Hannchen barley in awned and clipped spikes at Aberdeen, Idaho, in 1916*—Continued

Normal spikes.								Clipped spikes.							
Weight.		Length.		Lateral diameter.		Dorso-ventral diameter.		Weight.		Length.		Lateral diameter.		Dorso-ventral diameter.	
A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
Gm.	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
JULY 12															
0.0020	0.0037	2.8	3.2	1.2	1.4	0.7	1.0	0.0023	0.0042	2.6	3.4	1.2	1.5	0.8	0.8
.0044	.0065	3.7	4.6	1.4	1.5	.9	1.0	.0058	.0055	4.6	4.5	1.5	1.7	.9	1.0
.0055	.0073	4.3	4.9	1.7	1.7	1.0	1.0	.0075	.0074	5.6	5.3	1.7	1.6	.9	.9
.0074	.0086	5.2	6.0	1.6	1.7	1.0	.9	.0090	.0083	6.5	5.7	1.6	1.7	.9	1.1
.0074	.0090	5.3	5.9	1.6	1.8	1.0	1.1	.0088	.0091	6.7	6.6	1.7	1.7	.9	1.0
.0081	.0096	5.6	6.4	1.8	1.8	1.0	1.0	.0098	.0099	6.9	6.9	1.7	1.7	.9	1.0
.0085	.0098	6.0	6.5	1.8	1.8	1.0	1.0	.0096	.0098	6.9	6.9	1.8	1.7	1.0	1.0
.0092	.0098	6.3	6.5	1.7	1.7	1.0	1.0	.0097	.0102	7.3	7.1	1.7	1.8	1.0	1.1
.0092	.0099	6.5	6.7	1.8	1.7	1.0	1.0	.0100	.0100	7.3	6.9	1.7	1.8	1.0	1.1
.0092	.0098	6.6	7.0	1.8	1.7	1.0	1.1	.0090	.0104	7.0	7.4	1.8	1.7	1.0	1.1
.0087	.0097	6.9	6.6	1.7	1.8	1.0	1.0	.0089	.0097	6.9	7.1	1.7	1.5	1.0	1.1
.0085	.0085	6.3	6.3	1.8	1.7	1.0	1.0	.0080	.0082	6.4	6.1	1.6	1.6	1.0	1.0
.0077	.0028	6.2	S.	1.7	......	1.0	......	.0069	.0073	5.8	5.5	1.6	1.6	.8	.9
.0068	.0062	5.7	5.3	1.6	1.4	1.0	1.0	.0052	.0062	4.9	5.5	1.4	1.5	.1	.8
.0050	.0044	4.3	4.2	1.5	1.4	1.0	.9	......	.0050	......	4.7	......	1.5	......	.8
JULY 13															
0.0102	0.0071	6.8	5.4	1.9	1.7	1.1	1.0	0.0037	0.0064	4.8	5.3	1.6	1.5	0.7	0.9
.0130	.0114	8.2	7.5	1.9	1.8	1.2	1.1	.0103	.0094	7.2	6.6	1.8	1.7	1.0	1.0
.0146	.0121	8.6	7.5	1.9	1.8	1.2	1.1	.0140	.0116	8.3	7.5	1.9	1.7	1.3	1.2
.0153	.0145	9.2	8.5	2.0	1.9	1.4	1.2	.0155	.0125	8.8	8.3	2.0	1.7	1.4	1.1
.0160	.0146	9.3	8.9	2.0	1.9	1.4	1.2	.0169	.0141	9.2	8.5	2.0	1.9	1.5	1.2
.0175	.0157	9.6	8.8	2.2	1.9	1.5	1.4	.0184	.0145	9.5	8.8	2.1	2.0	1.5	1.4
.0187	.0168	10.0	9.1	2.2	2.0	1.4	1.4	.0184	.0144	9.4	8.7	2.1	1.8	1.5	1.3
.0188	.0162	10.0	9.3	2.1	2.2	1.4	1.4	.0179	.0149	9.0	8.8	2.0	1.9	1.4	1.3
.0184	.0172	9.9	9.6	2.2	2.0	1.5	1.5	.0178	.0145	9.2	8.4	2.2	1.9	1.5	1.4
.0173	.0167	9.5	9.3	2.2	2.0	1.4	1.4	.0196	.0147	9.0	8.5	2.3	1.9	1.5	1.2
.0175	.0149	9.6	9.1	2.1	1.9	1.5	1.4	.0160	.0149	9.0	8.5	2.0	1.9	1.4	1.3
.0158	.0137	9.3	8.7	2.1	1.9	1.4	1.4	.0138	.0137	8.7	8.5	1.9	1.9	1.4	1.3
.0135	.0129	8.6	8.5	1.9	1.8	1.3	1.2	.0126	.0127	8.5	8.3	1.9	1.9	1.2	1.3
.0126	.0103	8.5	7.3	1.9	1.7	1.4	1.1	.0086	.0106	7.0	7.7	1.6	1.7	1.1	1.2
.0105	.0085	7.7	6.9	2.0	1.5	1.1	1.0	......	.0082	......	6.7	......	1.6	......	.8
.0076	......	6.3	......	1.7	......	.9	......	......	......	......	......	......	......	......	......
JULY 14															
0.0069	0.0104	5.3	7.3	1.7	1.9	0.9	1.1	0.0094	0.0098	7.3	7.3	1.7	1.8	1.0	1.2
.0117	.0153	7.6	8.4	1.8	2.1	1.1	1.3	.0139	.0108	8.6	9.1	1.8	2.1	1.4	1.4
.0151	.0161	8.7	9.0	2.1	2.1	1.3	1.4	.0167	.0200	9.3	9.4	1.9	2.2	1.6	1.5
.0154	.0179	9.0	9.1	2.0	2.1	1.3	1.5	.0173	.0207	9.6	9.8	2.0	2.0	1.5	1.5
.0177	.0196	9.4	9.4	2.1	2.3	1.4	1.6	.0191	.0220	9.6	9.9	2.1	2.2	1.5	1.6
.0182	.0199	9.5	9.6	2.2	2.1	1.4	1.6	.0189	.0227	9.7	10.2	2.0	2.3	1.6	1.6
.0180	.0203	9.7	9.7	2.0	2.1	1.4	1.5	.0196	.0244	9.9	10.4	2.3	2.3	1.5	1.7
.0185	.0208	9.4	9.5	2.1	2.1	1.5	1.7	.0195	.0250	9.9	10.5	2.3	2.4	1.5	1.7
.0186	.0208	10.0	9.9	2.2	1.9	1.5	1.6	.0194	.0247	9.6	10.4	2.2	2.5	1.6	1.6
.0171	.0209	9.4	10.0	2.1	2.3	1.5	1.5	.0193	.0242	9.6	9.9	2.3	2.5	1.5	1.7
.0159	.0192	9.5	9.6	1.9	2.3	1.4	1.6	.0164	.0236	9.4	10.3	1.9	2.6	1.4	1.6
.0134	.0179	8.8	9.3	1.9	2.2	1.3	1.5	.0146	.0222	8.8	10.0	1.9	2.3	1.3	1.7
.0110	.0152	8.0	8.7	1.7	2.0	1.1	1.4	.0138	.0205	8.9	10.0	1.8	2.3	1.4	1.5
.0094	.0128	7.5	8.5	1.8	1.9	1.1	1.2	.0100	.0171	7.8	9.5	1.7	2.1	1.2	1.4
......	.0090	......	7.3	......	1.6	......	1.2	......	.0145	......	8.5	......	2.0	......	1.4

TABLE IV.—*Growth of kernels of Hannchen barley in awned and clipped spikes at Aberdeen, Idaho, in 1916*—Continued

JULY 15

Normal spikes.								Clipped spikes.							
Weight.		Length.		Lateral diameter.		Dorso-ventral diameter.		Weight.		Length.		Lateral diameter.		Dorso-ventral diameter.	
A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
Gm.	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
0.0082	0.0045	6.4	5.0	1.8	1.5	0.9	0.7	0.0041	0.0058	4.8	5.5	1.4	1.5	0.7	0.8
.0158	.0017	8.7	8.8	1.9	2.1	1.3	1.4	.0144	.0145	8.8	8.8	1.9	1.9	1.4	1.3
.0193	.0213	9.6	9.5	2.1	2.2	1.4	1.6	.0207	.0144	9.5	9.6	2.3	2.2	1.5	1.5
.0215	.0248	10.0	9.8	2.1	2.1	1.5	1.6	.0251	.0212	10.1	9.3	2.3	2.2	1.8	1.5
.0230	.0261	10.0	10.2	2.3	2.3	1.6	1.6	.0253	.0215	10.1	9.5	2.2	2.3	1.7	1.5
.0261	.0265	10.4	10.0	2.3	2.0	1.4	1.7	.0263	.0230	10.0	9.5	2.4	2.4	1.8	1.5
.0258	.0284	10.1	10.4	2.4	2.4	1.6	1.9	.0264	.0246	10.0	9.7	2.5	2.3	1.7	1.8
.0253	.0282	10.1	10.4	2.3	2.6	1.6	1.8	.0275	.0243	10.0	9.6	2.5	2.4	1.7	1.6
.0259	.0269	10.0	10.0	2.5	2.5	1.6	1.7	.0267	.0248	10.0	10.0	2.6	2.3	1.9	1.7
.0250	.0266	10.3	10.0	2.2	2.0	1.7	1.6	.0260	.0235	9.9	9.3	2.5	2.3	1.7	1.5
.0229	.0253	10.0	10.0	2.0	2.2	1.5	1.5	.0250	.0210	9.7	9.3	2.2	2.4	1.5	1.5
.0212	.0231	9.5	9.7	2.0	2.2	1.5	1.8	.0237	.0180	9.5	9.3	2.2	2.0	1.5	1.5
.0183	.0213	9.5	9.0	2.0	2.0	1.5	1.7	.0206	.0134	9.1	8.5	2.2	1.9	1.5	1.4
.0172	.0169	9.3	9.0	2.0	2.1	1.5	1.5	.0175	....	9.2	......	2.0	......	1.5	.....
.0141	.0135	8.7	8.2	1.6	1.8	1.4	1.3	.0119	....	7.7	......	1.8	......	1.3	.....

JULY 17

0.0167	0.0293	9.2	10.3	2.3	2.7	1.4	2.0	0.0223	0.0225	9.5	8.3	2.6	1.9	1.5	1.4
.0334	.0323	10.2	10.5	2.8	2.9	2.2	2.2	.0340	.0254	10.4	10.0	3.0	2.5	2.0	1.8
.0370	.0363	10.6	10.6	2.9	3.0	2.1	2.1	.0366	.0298	10.0	10.2	3.0	2.8	2.0	1.8
.0411	.0396	10.9	11.2	3.1	3.0	2.3	2.1	.0398	.0339	10.4	10.0	3.2	3.0	2.2	2.1
.0404	.0400	11.1	10.6	3.1	3.1	2.3	2.2	.0384	.0351	10.0	10.0	3.2	3.0	2.2	2.0
.0436	.0413	11.0	10.2	3.3	3.0	2.2	2.1	.0388	.0368	9.8	10.5	3.2	3.2	2.0	2.1
.0436	.0423	11.2	10.3	3.2	3.3	2.3	2.2	.0385	.0362	9.7	9.2	3.2	3.2	2.1	2.1
.0442	.0406	11.1	10.5	3.2	3.2	2.3	2.2	.0393	.0344	9.8	9.4	3.2	3.0	2.2	2.2
.0447	.0413	10.6	10.2	3.4	3.2	2.3	2.2	.0385	.0349	9.7	9.8	3.2	3.0	2.2	2.0
.0422	.0392	10.5	10.3	3.3	3.0	2.4	2.0	.0384	.0315	9.8	9.5	3.4	3.0	2.3	1.9
.0405	.0392	10.6	10.0	3.3	3.1	2.3	2.0	.0339	.0299	9.7	9.1	3.0	3.0	2.1	2.0
.0387	.0375	10.4	9.8	3.3	3.0	2.2	2.1	.0316	.0277	8.9	8.9	3.1	2.9	2.0	1.9
.0365	.0343	10.0	9.5	3.1	3.0	2.2	2.2	.0298	.0245	9.0	8.6	2.8	2.7	1.9	1.9
.0314	.0320	9.7	9.8	2.8	2.9	2.0	2.1	.0255	.0166	9.1	7.9	2.5	2.5	1.6	1.6
.0260	.0287	9.5	9.0	2.6	2.8	1.8	2.0	.0201	....	8.2	......	2.5	......	1.6	.....

JULY 18

0.0253	0.0279	9.3	9.3	2.7	2.9	1.6	1.8	0.0283	0.0191	10.0	8.7	2.8	2.3	1.8	1.6
.0390	.0395	10.5	10.7	3.2	3.0	2.1	2.2	.0326	.0317	10.3	10.2	2.8	2.7	1.8	1.7
.0405	.0450	10.4	10.3	3.3	3.4	2.1	2.2	.0368	.0369	10.0	10.7	3.1	3.0	2.1	2.0
.0450	.0466	10.2	10.0	3.4	3.3	2.2	2.3	.0386	.0410	10.3	10.4	3.2	3.3	2.0	2.2
.0439	.0478	11.0	10.5	3.2	3.4	2.2	2.4	.0417	.0430	10.1	10.2	3.1	3.2	2.3	2.2
.0455	.0508	10.7	10.4	3.3	3.6	2.3	2.5	.0423	.0434	10.2	10.1	3.0	3.3	2.2	2.2
.0465	.0504	10.1	10.7	3.5	3.5	2.2	2.6	.0418	.0427	10.0	9.3	3.2	3.3	2.2	2.2
.0458	.0500	10.5	10.8	3.4	3.6	2.3	2.4	.0408	.0441	9.6	10.2	3.3	3.2	2.2	2.2
.0439	.0431	9.5	10.2	3.4	3.6	2.0	2.4	.0388	.0454	9.8	10.2	3.2	3.3	2.2	2.5
.0430	.0468	9.7	10.1	3.4	3.4	2.1	2.4	.0390	.0415	9.7	9.7	3.2	3.3	2.3	2.4
.0419	.0431	10.1	9.5	3.3	3.5	2.3	2.4	.0334	.0402	9.2	10.1	3.2	3.2	2.0	2.1
.0383	.0416	9.7	9.1	3.3	3.4	2.3	2.4	.0305	.0387	9.2	9.6	3.0	3.1	2.0	2.3
.0324	.0388	9.3	9.3	2.8	3.3	1.9	2.2	.0271	.0353	8.7	9.7	2.8	3.2	1.7	2.2
.0311	.0350	8.6	9.2	2.9	3.1	2.0	2.2	.0197	.0330	7.8	9.2	2.5	3.0	1.5	2.1
....	....	.....	.....	.....	.....	.....	.....	....	.0279	......	8.4	......	2.8	....	1.9

TABLE IV.—*Growth of kernels of Hannchen barley in awned and clipped spikes at Aberdeen, Idaho, in 1916*—Continued

Normal spikes.								Clipped spikes.							
Weight.		Length.		Lateral diameter.		Dorso-ventral diameter.		Weight.		Length.		Lateral diameter.		Dorso-ventral diameter.	
A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
JULY 19															
Gm.	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
0.0205	0.0337	9.2	9.7	2.5	3.1	1.7	2.1	0.0137	0.0253	7.5	9.5	2.2	2.9	1.5	1.7
.0391	.0427	10.1	10.6	3.2	3.3	2.1	2.2	.0324	.0374	9.8	9.5	2.8	3.2	2.0	2.0
.0396	.0475	10.4	10.5	3.3	3.4	2.1	2.5	.0380	.0409	10.1	10.2	3.2	3.3	2.2	2.3
.0445	.0511	9.9	10.8	3.3	3.5	2.3	2.3	.0408	.0422	10.1	10.4	3.4	3.3	2.3	2.1
.0457	.0481	10.4	10.7	3.4	3.7	2.3	2.5	.0397	.0441	10.1	10.2	3.4	3.4	2.3	2.3
.0473	.0489	10.3	10.5	3.4	3.5	2.3	2.3	.0429	.0425	10.4	10.4	3.3	3.3	2.4	2.1
.0465	.0486	10.3	10.4	3.4	3.6	2.5	2.5	.0431	.0435	9.6	9.7	3.3	3.4	2.4	2.2
.0462	.0488	9.6	10.8	3.5	3.5	2.5	2.4	.0409	.0443	9.6	9.7	3.2	3.4	2.4	2.3
.0467	.0483	10.2	10.0	3.4	3.5	2.4	2.5	.0382	.0434	9.7	9.6	3.3	3.4	2.2	2.4
.0405	.0459	10.2	10.0	3.4	3.4	2.2	2.2	.0391	.0402	9.6	9.9	3.4	3.3	2.4	2.2
.0448	.0457	9.7	9.7	3.5	3.4	2.3	2.5	.0373	.0388	9.2	9.6	3.4	3.4	2.1	2.2
.0400	.0438	9.6	10.1	3.2	3.4	2.4	2.3	.0343	.0363	8.7	9.6	3.2	3.3	2.1	2.1
.0381	.0375	9.6	9.2	3.2	3.3	2.3	2.3	.0311	.0328	8.9	8.6	3.0	3.2	2.1	2.2
.0356	.0345	9.2	9.6	3.3	3.2	2.3	2.1	.0226	.0264	8.2	8.7	2.8	3.0	1.8	1.9
.0278	......	9.0	......	3.0	......	2.2	......	......	.0198	......	8.0	......	2.6	......	1.6
JULY 20															
0.0117	0.0356	7.6	10.7	2.1	3.1	1.3	2.2	0.0395	0.0359	10.8	9.8	3.2	3.1	2.0	2.3
.0419	.0421	10.3	11.0	3.3	3.4	2.3	2.3	.0435	.0407	10.4	10.2	3.3	3.3	2.3	2.3
.0477	.0422	10.3	10.2	3.6	3.2	2.5	2.2	.0315	.0437	9.9	10.5	3.0	3.2	1.6	2.4
.0492	.0447	10.6	11.0	3.6	3.3	2.5	2.3	.0510	.0442	10.8	10.8	3.5	3.1	2.5	2.3
.0521	.0467	10.7	11.0	3.8	3.2	2.4	2.3	.0478	.0460	10.4	10.4	3.5	3.4	2.1	2.4
.0500	.0455	10.8	10.9	3.6	3.3	2.4	2.3	.0491	.0456	10.5	10.4	3.5	3.3	2.5	2.1
.0505	.0440	10.7	10.6	3.7	3.2	2.4	2.2	.0433	.0450	10.4	10.1	3.4	3.3	2.3	2.5
.0514	.0458	10.4	10.3	3.6	3.3	2.5	2.5	.0470	.0430	10.2	10.1	3.5	3.3	2.2	2.2
.0492	.0444	10.0	10.5	3.5	3.3	2.5	2.3	.0442	.0400	10.2	9.3	3.5	3.0	2.4	2.1
.0495	.0443	10.4	10.0	3.6	3.3	2.5	2.3	.0410	.0403	10.2	9.8	3.4	3.0	2.2	2.0
.0475	.0419	10.0	10.4	3.5	3.3	2.4	2.3	.0392	.0384	9.9	9.7	3.2	2.9	2.3	2.1
.0455	.0409	10.0	9.7	3.4	3.2	2.4	2.2	.0365	.0332	9.8	9.7	3.2	3.1	2.2	2.1
.0411	.0363	9.7	9.7	3.5	3.2	2.3	2.0	.0320	.0293	9.3	8.9	3.2	2.9	2.0	2.0
.0382	.0331	9.6	9.8	3.3	2.8	2.3	2.0	.0247	.0199	9.0	8.5	2.9	2.7	1.8	1.7
.0326	.0280	9.3	9.1	2.8	2.8	2.0	2.0	......	......	......	......	......	......	......	......
July 21															
0.0200	0.0228	8.9	9.3	2.4	2.6	1.7	1.8	0.0257	0.0355	9.4	9.8	2.8	3.2	1.9	1.9
.0446	.0420	10.6	10.3	3.4	3.2	2.2	2.2	.0427	.0433	10.0	10.2	3.5	3.5	2.4	2.3
.0522	.0492	10.7	11.0	3.5	3.5	2.3	2.3	.0462	.0411	10.6	10.4	3.4	3.5	2.3	2.2
.0538	.0505	10.8	11.0	3.7	3.6	2.4	2.2	.0465	.0488	10.2	10.5	3.3	3.5	2.2	2.3
.0596	.0527	10.6	10.6	3.9	3.6	2.4	2.5	.0508	.0489	10.3	10.8	3.5	3.7	2.5	2.3
.0487	.0505	10.7	10.6	3.7	3.4	2.4	2.5	.0492	.0473	9.4	10.1	3.7	3.5	2.4	2.3
.0542	.0517	10.7	11.0	3.8	3.6	2.5	2.5	.0477	.0463	10.0	9.8	3.5	3.5	2.4	2.3
.0555	.0517	10.7	10.6	3.8	3.4	2.6	2.4	.0456	.0461	10.3	10.3	3.5	3.5	2.3	2.3
.0555	.0514	10.8	10.3	3.8	3.7	2.5	2.5	.0454	.0455	10.0	9.7	3.5	3.4	2.3	2.2
.0509	.0490	10.4	10.3	3.8	3.5	2.5	2.4	.0439	.0429	9.5	9.9	3.5	3.5	2.3	2.4
.0489	.0481	10.3	10.5	3.7	3.5	2.6	2.4	.0416	.0416	10.0	9.8	3.5	3.1	2.1	2.2
.0475	.0442	10.1	10.3	3.7	3.5	2.5	2.4	.0387	.0419	9.0	9.5	3.1	3.3	2.1	2.3
.0434	.0412	10.1	9.6	3.6	3.4	2.4	2.3	.0359	.0356	9.6	9.3	3.2	3.3	2.3	2.1
.0412	.0373	10.0	9.7	3.4	3.3	2.2	2.2	.0333	.0350	9.1	9.0	3.2	3.2	2.2	2.0
.0339	.0289	9.5	9.1	3.2	3.1	2.3	2.0	.0212	......	8.4	......	2.7	......	1.9	......

TABLE IV.—*Growth of kernels of Hannchen barley in awned and clipped spikes at Aberdeen, Idaho, in 1916*—Continued

July 22

Normal spikes.								Clipped spikes.							
Weight.		Length.		Lateral diameter.		Dorso-ventral diameter.		Weight.		Length.		Lateral diameter.		Dorso-ventral diameter.	
A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
Gm.	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
0.0300	0.0164	9.6	8.0	2.8	2.5	1.8	1.8	0.0203	0.0238	8.2	9.0	2.5	2.5	1.5	1.7
.0558	.0433	10.8	10.5	3.8	3.5	2.6	2.6	.0437	.0382	10.0	10.0	3.5	3.2	2.0	1.9
.0580	.0493	10.9	10.4	3.8	3.5	2.6	2.6	.0544	.0464	10.2	9.8	3.7	3.4	2.3	2.1
.0593	.0526	10.8	10.7	3.6	3.6	2.4	2.4	.0575	.0473	10.4	10.1	3.6	3.5	2.3	2.1
.0600	.0494	10.8	9.8	4.0	3.4	2.6	2.6	.0575	.0524	10.8	10.5	3.7	3.5	2.5	2.5
.0570	.0519	10.5	10.7	3.7	3.6	2.3	2.3	.0550	.0503	10.4	9.5	3.8	3.5	2.5	2.3
.0595	.0539	10.5	10.0	3.9	3.5	2.6	2.6	.0563	.0546	10.0	10.0	3.9	3.7	2.5	2.4
.0599	.0493	10.7	10.0	3.8	3.6	2.7	2.7	.0557	.0523	10.0	10.4	3.6	3.6	2.5	2.5
.0605	.0516	10.5	9.7	3.9	3.5	2.7	2.7	.0557	.0514	9.5	9.7	3.6	3.7	2.5	2.5
.0582	.0504	10.5	10.5	3.9	3.6	2.8	2.8	.0495	.0503	9.9	10.0	3.6	3.5	2.3	2.5
.0566	.0487	10.5	10.1	3.8	3.5	2.6	2.6	.0478	.0483	9.5	10.2	3.5	3.5	2.3	2.5
.0538	.0486	10.0	10.0	3.5	3.5	2.4	2.4	.0460	.0462	10.0	9.6	3.4	3.5	2.1	2.3
.0505	.0464	10.0	9.8	3.6	3.6	2.4	2.4	.0432	.0428	9.0	9.4	3.7	3.5	2.3	2.2
.0479	.0413	9.2	9.5	3.6	3.2	2.5	2.5	.0388	.0405	9.3	9.1	3.0	3.4	2.1	2.2
.0419	.0385	9.0	9.0	3.5	3.1	2.4	2.4	.0281	.0325	9.7	8.3	2.8	3.1	1.9	2.0

JULY 24

0.0491	0.0513	10.3	10.2	3.7	3.6	2.4	2.5	0.0294	0.0489	9.3	9.6	3.0	3.6	1.7	2.4
.0591	.0577	10.5	10.7	3.7	3.6	2.6	2.5	.0524	.0561	10.5	10.6	3.7	3.7	2.3	2.5
.0596	.0606	10.5	10.7	3.9	3.8	2.7	2.7	.0576	.0534	10.5	10.5	3.9	3.7	2.4	2.3
.0633	.0593	10.5	10.8	3.9	3.8	2.9	2.5	.0588	.0595	10.6	10.7	3.9	3.8	2.5	2.5
.0607	.0629	10.5	10.8	3.9	3.9	2.5	2.7	.0632	.0587	10.7	10.5	4.0	3.7	2.6	2.4
.0645	.0658	10.5	10.8	4.2	4.0	2.6	2.8	.0585	.0562	10.5	10.3	3.9	3.7	2.6	2.6
.0625	.0659	10.7	10.4	3.8	4.0	2.7	2.8	.0602	.0612	10.3	10.1	3.9	3.8	2.7	2.7
.0580	.0690	10.3	10.8	3.9	4.1	2.6	2.9	.0555	.0575	10.4	10.0	3.7	3.7	2.5	2.8
.0605	.0648	10.5	10.6	3.8	4.0	2.6	2.7	.0515	.0557	10.0	9.9	3.5	3.7	2.5	2.5
.0608	.0634	10.5	10.4	3.8	3.8	2.7	2.8	.0544	.0544	10.2	9.6	3.6	3.7	2.5	2.6
.0531	.0532	10.2	10.4	3.8	3.7	2.5	2.7	.0528	.0508	9.8	9.1	3.6	3.6	2.4	2.5
.0534	.0559	10.2	10.2	3.7	3.7	2.5	2.5	.0490	.0440	9.5	9.7	3.6	3.5	2.3	2.4
.0470	.0554	9.5	9.6	3.5	3.7	2.4	2.6	.0453	.0453	9.6	8.8	3.4	3.4	2.4	2.5
.0454	.0527	9.1	10.0	3.4	3.6	2.5	2.7	.0373	......	9.1	......	3.1	......	2.1	......
......	.0450	......	9.3	......	3.4	......	2.5	......	......	......	......	......	......	......	......
......	.0388	......	8.7	......	3.3	......	2.3	......	......	......	......	......	......	......	......

JULY 25

0.0300	0.9552	8.7	10.4	2.9	3.7	1.9	2.4	0.0480	0.0235	10.0	8.5	3.6	2.6	2.4	1.5
.0583	.0624	10.4	10.9	3.7	3.9	2.5	2.7	.0600	.0465	10.8	9.5	3.7	3.6	2.5	2.3
.0605	.0603	10.9	10.5	3.8	3.7	2.6	2.6	.0624	.0485	11.0	10.0	3.8	3.5	2.7	2.5
.0650	.0633	11.0	10.7	3.9	4.0	2.7	2.6	.0604	.0517	10.7	9.4	3.6	3.7	2.6	2.3
.0608	.0636	10.3	11.0	3.8	3.9	2.7	2.6	.0660	.0531	10.6	10.5	4.0	3.6	2.7	2.4
.0650	.0619	10.8	10.5	3.8	3.7	2.7	2.5	.0653	.0528	11.0	9.5	3.9	3.7	2.7	2.3
.0639	.0613	10.6	10.8	3.7	3.8	2.8	2.7	.0635	.0502	11.0	10.2	3.6	3.7	2.5	2.4
.0628	.0587	10.6	10.3	3.8	3.7	2.6	2.6	.0634	.0515	10.8	10.2	3.7	3.4	2.3	2.4
.0629	.0608	10.4	10.6	3.8	3.8	2.8	2.7	.0638	.0515	10.0	9.9	3.6	3.4	2.8	2.4
.0615	.0590	10.4	10.3	4.0	3.8	2.5	2.7	.0593	.0500	10.3	10.0	3.9	3.7	2.6	2.4
.0577	.0573	10.2	10.3	3.6	3.8	2.7	2.7	.0585	.0483	10.5	9.6	3.5	3.6	2.5	2.5
.0568	.0569	10.1	9.7	3.8	3.5	2.6	2.6	.0578	.0482	10.2	9.5	3.7	3.4	2.7	2.4
.0548	.0556	9.7	9.6	3.7	3.7	2.6	2.5	.0569	.0430	10.0	9.3	3.6	3.0	2.6	2.2
.0526	.0500	9.7	9.5	3.4	3.5	2.8	2.6	.0483	.0418	9.7	9.3	3.5	3.0	2.5	2.3
.0475	.0461	9.0	9.2	3.6	3.1	2.5	2.4	.0400	.0335	9.0	8.6	3.1	3.1	2.1	2.0
.0392	.0364	9.0	9.0	3.3	3.3	2.3	2.1	......	......	......	......	......	......	......	......

TABLE IV.—*Growth of kernels of Hannchen barley in awned and clipped spikes at Aberdeen, Idaho, in 1916*—Continued

JULY 26

Normal spikes.								Clipped spikes.							
Weight.		Length.		Lateral diameter.		Dorso-ventral diameter.		Weight.		Length.		Lateral diameter.		Dorso-ventral diameter.	
A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
Gm.	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
0.0304	0.0382	9.2	9.2	3.0	3.3	1.8	2.0	0.0394	0.0368	9.0	9.0	3.3	3.0	2.0	1.8
.0569	.0588	9.7	10.8	3.5	3.8	2.6	2.5	.0547	.0614	10.8	10.0	3.7	3.5	2.3	2.5
.0619	.0640	9.7	10.8	3.9	3.5	2.4	2.5	.0614	.0642	10.5	10.5	3.7	3.5	2.7	2.7
.0660	.0700	10.7	10.8	3.8	3.9	2.7	2.6	.0670	.0669	10.7	10.8	3.8	3.7	2.5	2.7
.0708	.0659	10.7	10.5	4.0	4.0	2.8	2.6	.0655	.0652	10.6	10.5	3.7	3.7	2.6	2.5
.0669	.0672	10.7	10.9	3.8	4.0	2.8	2.8	.0658	.0624	10.5	10.5	3.7	3.8	2.8	2.5
.0650	.0673	10.2	10.7	3.7	3.9	2.6	2.8	.0651	.0657	10.7	10.5	3.7	3.7	2.8	2.8
.0696	.0671	10.8	11.0	3.9	3.9	2.7	2.6	.0665	.0643	10.5	10.2	3.9	3.9	2.8	2.7
.0681	.0645	10.2	10.3	3.8	3.8	2.6	2.6	.0650	.0600	10.3	10.0	3.8	3.7	2.6	2.5
.0654	.0634	10.4	10.3	3.7	3.6	2.6	2.5	.0653	.0600	10.3	10.0	3.7	3.8	2.7	2.6
.0640	.0626	10.4	10.4	3.8	3.8	2.7	2.6	.0602	.0568	10.0	10.0	3.8	3.4	2.7	2.5
.0607	.0557	10.0	9.7	3.9	3.7	2.5	2.5	.0588	.0530	10.0	9.5	3.6	3.5	2.7	2.5
.0607	.0540	10.0	9.6	3.7	3.6	2.5	2.6	.0505	.0486	9.5	9.2	3.2	3.5	2.5	2.5
.0546	.0485	9.5	8.9	3.5	3.5	2.5	2.6	.0456	.0353	9.0	8.7	3.5	3.2	2.3	1.9
.0502	......	9.5	......	3.5	......	2.5	......	.0332	......	8.0	......	3.3	......	2.0	.....

JULY 27

0.0541	0.0427	10.0	9.3	3.5	3.0	2.5	2.1	0.0275	0.0357	8.5	9.5	2.5	3.0	2.0	2.0
.0558	.0614	10.3	10.2	3.7	3.2	2.5	2.4	.0458	.0618	9.8	10.0	3.5	3.9	2.2	2.6
.0604	.0653	10.5	10.5	3.5	3.6	2.5	2.5	.0538	.0662	10.0	10.5	3.5	3.6	2.5	2.8
.0620	.0685	10.5	10.5	3.8	3.8	2.6	2.7	.0581	.0622	10.1	10.0	3.7	3.8	2.3	2.7
.0609	.0655	10.0	10.5	3.8	3.8	2.5	2.4	.0583	.0656	10.2	10.3	3.5	3.8	2.5	2.8
.0592	.0664	10.0	10.2	3.6	3.8	2.5	2.6	.0552	.0637	10.2	10.3	3.2	3.9	2.5	2.7
.0583	.0656	9.6	10.4	3.6	3.8	2.6	2.7	.0567	.0656	9.4	9.6	3.4	3.7	2.4	2.6
.0600	.0622	9.6	10.0	3.6	3.7	2.5	2.6	.0579	.0615	9.8	10.2	3.6	3.7	2.7	2.7
.0554	.0629	9.3	10.0	3.5	3.5	2.5	2.5	.0538	.0619	9.8	9.8	3.4	3.7	2.6	2.6
.0562	.0627	9.6	9.5	3.7	3.9	2.6	2.6	.0516	.0579	9.8	10.0	3.4	3.6	2.3	2.7
.0530	.0603	9.2	9.0	3.5	3.6	2.5	2.7	.0487	.0564	9.0	9.2	3.5	3.4	2.5	2.3
.0488	.0589	9.2	9.5	3.4	3.7	2.3	2.7	.0486	.0518	9.6	9.0	3.5	3.3	2.6	2.4
.0457	.0545	9.0	9.2	3.2	3.5	2.3	2.4	.0416	.0471	9.0	9.5	3.3	3.5	2.2	2.4
......	.0475	......	8.8	......	3.3	......	2.4	.0224	.0343	8.3	9.2	2.7	3.2	1.8	2.1

JULY 28

0.0345	0.0190	8.5	7.2	3.2	2.5	1.8	1.6	0.0362	0.0233	9.1	7.7	3.4	2.7	2.1	1.8
.0589	.0574	10.5	10.0	3.6	3.5	2.5	2.7	.0530	.0552	9.8	10.0	3.7	3.4	2.3	2.8
.0640	.0637	10.8	10.0	4.0	3.8	2.6	2.7	.0602	.0619	10.0	10.5	3.8	3.8	2.7	2.5
.0652	.0651	11.0	10.6	3.8	3.8	2.6	2.8	.0614	.0603	10.0	10.5	3.7	3.7	2.5	2.6
.0688	.0671	10.7	10.0	4.0	4.0	2.7	2.8	.0642	.0632	10.7	10.5	3.8	3.7	2.7	2.5
.0667	.0658	10.6	11.0	3.8	3.8	2.8	2.7	.0625	.0638	10.0	10.0	3.8	3.7	2.7	2.8
.0657	.0688	10.0	10.5	3.8	3.7	2.9	2.8	.0619	.0660	9.9	10.0	3.8	3.5	2.8	2.8
.0625	.0683	10.5	10.2	3.8	4.0	2.7	2.8	.0604	.0616	9.8	10.2	3.8	3.7	2.8	2.7
.0608	.0695	9.6	10.4	3.8	4.0	2.7	2.9	.0585	.0600	10.0	10.0	3.7	3.5	2.8	2.7
.0618	.0657	10.0	10.0	3.7	3.9	2.6	2.8	.0578	.0585	9.3	10.2	3.8	3.7	2.5	2.6
.0578	.0620	9.8	9.5	3.5	3.7	3.7	2.7	.0560	.0560	9.7	10.1	3.7	3.7	2.7	2.6
.0547	.0602	10.0	10.0	3.7	3.8	2.6	2.8	.0512	.0572	9.0	10.0	3.5	3.7	2.3	2.8
.0502	.0575	9.7	9.7	3.7	3.7	2.5	2.6	.0504	.0528	9.0	9.4	3.4	3.5	2.4	2.6
.0452	.0502	9.2	9.4	3.5	3.6	2.5	2.6	.0441	.0485	8.7	9.0	3.4	3.3	2.4	2.6
......	.0489	......	9.2	......	3.6	......	2.5	.0279	.0427	8.0	8.5	2.8	3.4	1.9	2.5

TABLE IV.—*Growth of kernels of Hannchen barley in awned and clipped spikes at Aberdeen, Idaho, in 1916*—Continued

Normal spikes.								Clipped spikes.							
Weight.		Length.		Lateral diameter.		Dorso-ventral diameter.		Weight.		Length.		Lateral diameter.		Dorso-ventral diameter.	
A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
JULY 29															
Gm.	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
0.0360	0.0454	9.0	9.2	3.3	3.5	2.1	2.3	0.0523	0.0500	9.8	10.0	3.5	3.5	2.3	2.3
.0686	.0685	10.3	10.5	3.9	3.7	2.7	2.7	.0650	.0616	10.2	10.0	3.8	3.7	2.7	2.6
.0727	.0739	11.0	10.0	4.0	3.9	2.8	2.8	.0682	.0633	10.4	9.9	3.7	3.8	2.7	2.6
.0806	.0719	11.4	10.7	4.2	4.0	2.9	2.8	.0718	.0640	10.4	10.0	3.9	3.7	2.7	2.6
.0750	.0739	10.4	10.0	4.1	4.0	2.8	2.9	.0709	.0637	10.0	10.5	4.0	3.7	2.7	2.5
.0785	.0683	10.8	11.0	4.2	3.8	3.0	2.8	.0688	.0629	10.0	10.0	3.8	3.8	2.7	2.7
.0752	.0692	10.0	10.0	4.2	4.0	2.8	2.8	.0697	.0610	10.5	10.2	4.0	3.8	2.8	2.5
.0765	.0667	10.1	10.0	4.0	3.9	2.9	2.7	.0690	.0621	10.1	10.2	3.9	3.8	2.7	2.6
.0764	.0648	10.1	10.0	4.1	3.8	2.9	2.8	.0670	.0572	9.5	9.3	3.8	3.7	2.6	2.6
.0713	.0641	10.6	10.2	3.8	3.8	2.8	2.7	.0651	.0540	9.2	9.5	3.7	3.5	2.6	2.5
.0724	.0574	10.0	9.6	4.0	3.7	2.8	2.6	.0622	.0548	9.8	9.0	3.7	3.6	2.7	2.6
.0650	.0597	9.2	9.5	4.0	3.7	2.8	2.7	.0629	.0487	9.5	8.8	3.7	3.5	2.7	2.5
.0634	.0540	10.0	8.7	3.8	3.7	2.8	2.6	.0571	.0455	9.6	9.0	3.6	3.4	2.6	2.4
.0580	.0460	9.5	8.5	3.8	3.5	2.7	2.4	.0550	.0374	9.4	9.0	3.7	3.3	2.7	2.2
.0537	......	9.7	......	3.6	......	2.5	......	.0525	......	9.0	......	3.5	......	2.6	.....
......	......	......	......	......	......	......	......	.0445	......	8.6	......	3.5	......	2.3	.....
JULY 31															
0.0218	0.0513	7.9	9.5	2.8	3.5	1.7	2.3	0.0250	0.0451	8.4	9.5	2.8	3.4	1.8	2.3
.0600	.0735	9.9	11.7	3.8	4.0	2.7	2.8	.0592	.0566	9.8	10.0	3.7	3.7	2.5	2.4
.0689	.0785	10.5	11.5	3.9	4.0	2.7	2.9	.0625	.0620	10.0	10.3	3.7	3.5	2.5	2.5
.0677	.0726	10.5	11.0	3.9	4.0	2.8	2.8	.0624	.0672	10.1	9.8	3.8	3.8	2.6	2.6
.0735	.0740	10.6	10.0	3.9	4.0	2.8	2.7	.0633	.0643	10.3	10.1	3.7	3.7	2.6	2.7
.0743	.0660	11.0	9.8	4.0	3.7	2.9	2.6	.0651	.0642	10.3	10.4	3.8	3.7	2.8	2.6
.0704	.0687	11.0	10.5	3.9	3.9	2.9	2.8	.0636	.0625	10.2	9.7	3.7	3.7	2.6	2.7
.0692	.0725	10.4	10.8	4.0	3.8	2.8	2.8	.0622	.0631	10.2	10.0	3.7	3.7	2.6	2.7
.0656	.0689	10.4	10.5	3.8	3.7	2.7	2.8	.0590	.0608	9.7	10.2	3.7	3.7	2.6	2.6
.0689	.0679	10.0	10.5	3.9	3.8	2.8	2.8	.0588	.0590	9.9	10.0	3.8	3.7	2.6	2.7
.0630	.0685	10.0	10.8	3.8	3.8	2.7	2.8	.0588	.0554	9.5	9.6	3.7	3.7	2.7	2.6
.0627	.0668	10.0	10.5	3.7	3.9	2.7	2.8	.0570	.0564	9.3	9.5	3.7	3.6	2.5	2.5
.0582	.0649	9.7	10.2	3.7	3.7	2.6	2.7	.0511	.0468	9.4	10.0	3.6	3.5	2.5	2.5
.0517	.0605	9.5	9.6	3.5	3.6	2.5	2.6	.0493	.0459	9.3	9.2	3.5	3.4	2.5	2.4
.0518	.0550	8.8	9.2	3.5	3.5	2.6	2.6	.0422	.0429	8.6	8.9	3.4	3.3	2.4	2.4
.0430	.0388	8.6	8.0	3.4	3.1	2.5	2.3	.0241	......	8.0	......	2.7	......	2.0	.....
AUGUST 1															
0.0447	0.0494	9.5	9.5	3.2	3.4	2.4	2.4	0.0488	0.0330	9.6	8.3	3.5	3.1	2.5	2.1
.0655	.0641	10.0	10.0	3.8	3.8	2.8	2.7	.0644	.0589	10.3	10.0	3.7	3.7	2.7	2.6
.0664	.0692	10.2	10.4	3.8	3.9	2.8	2.7	.0634	.0636	10.3	10.7	3.7	3.8	2.7	2.7
.0694	.0682	10.7	10.5	4.0	3.9	2.7	2.7	.0648	.0653	10.5	9.8	3.7	3.9	2.7	2.7
.0704	.0660	10.7	10.8	3.9	3.8	2.6	2.8	.0659	.0663	10.5	10.1	3.7	3.9	2.6	2.8
.0713	.0632	10.4	10.4	3.8	3.7	2.7	2.7	.0650	.0666	10.3	10.0	3.7	3.8	2.7	2.8
.0705	.0650	10.5	10.0	3.9	3.8	2.9	2.7	.0627	.0611	10.4	10.0	3.7	3.7	2.8	2.6
.0687	.0675	10.0	10.4	3.9	3.9	2.8	2.6	.0592	.0623	9.8	9.9	3.7	3.7	2.7	2.6
.0678	.0661	10.0	10.2	3.9	3.8	2.9	2.7	.0588	.0612	10.1	9.9	3.7	3.7	2.7	2.7
.0650	.0655	10.5	10.0	3.8	3.8	2.9	2.8	.0578	.0568	10.2	10.0	3.7	3.6	2.7	2.6
.0639	.0651	10.0	9.9	3.8	3.8	2.8	2.8	.0519	.0540	9.6	9.3	3.7	3.6	2.6	2.6
.0590	.0625	9.9	10.1	3.8	3.8	2.8	2.8	.0539	.0500	9.0	9.6	3.7	3.5	2.7	2.6
.0627	.0554	9.7	9.5	3.8	3.5	2.8	2.6	.0511	.0464	9.0	9.2	3.7	3.4	2.5	2.5
.0571	.0588	9.5	9.3	3.7	3.7	2.8	2.8	.0500	.0461	9.0	9.8	3.6	3.5	2.5	2.5
.0490	.0516	9.5	8.6	3.6	3.6	2.7	2.7	.0443	.0370	9.1	8.5	3.4	3.2	2.5	2.3
.0376	.0424	8.5	8.3	3.3	3.4	2.4	2.6	.0342	......	9.5	......	3.2	......	2.4	.....

TABLE IV.—*Growth of kernels of Hannchen barley in awned and clipped spikes at Aberdeen, Idaho, in 1916*—Continued

AUGUST 2

Normal spikes.								Clipped spikes.							
Weight.		Length.		Lateral diameter.		Dorso-ventral diameter.		Weight.		Length.		Lateral diameter.		Dorso-ventral diameter.	
A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
Gm.	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Gm.*	*Gm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
0.0561	0.0404	9.8	9.0	3.7	3.2	2.6	2.3	0.0439	0.0232	9.1	7.7	3.2	2.7	2.3	1.6
.0605	.0600	10.0	9.6	3.7	3.6	2.6	2.7	.0614	.0577	10.0	10.0	3.7	3.7	2.6	2.5
.0606	.0617	10.5	10.7	3.8	3.7	2.7	2.6	.0632	.0614	10.3	11.0	3.7	3.7	2.7	2.6
.0604	.0631	9.7	10.5	3.7	3.7	2.6	2.7	.0612	.0625	10.0	10.0	3.5	3.7	2.7	2.7
.0564	.0654	10.3	10.3	3.6	3.8	2.6	2.8	.0598	.0580	9.5	10.3	3.5	3.5	2.7	2.6
.0542	.0633	9.7	10.5	3.6	3.7	2.5	2.8	.0600	.0564	9.3	10.3	3.6	3.5	2.6	2.5
.0545	.0605	9.8	10.1	3.5	3.7	2.6	2.8	.0557	.0562	9.6	10.1	3.6	3.5	2.6	2.6
.0541	.0585	10.2	10.0	3.5	3.7	2.6	2.8	.0525	.0514	9.5	9.7	3.5	3.4	2.8	2.6
.0512	.0484	9.5	10.0	3.5	3.2	2.7	2.5	.0482	.0459	8.8	9.2	3.4	3.4	2.7	2.5
.0430	.0518	9.5	9.4	3.3	3.4	2.5	2.7	.0460	.0420	9.1	9.5	3.4	3.3	2.7	2.5
.0500	.0485	9.2	9.0	3.4	3.4	2.6	2.7	.0418	.0440	8.7	9.0	3.4	3.4	2.6	2.5
.0403	.0455	8.8	8.9	3.2	3.4	2.4	2.6	.0380	.0363	8.2	9.2	3.2	3.1	2.5	2.1
.0310	.0373	8.5	8.6	2.9	3.2	2.5	2.5	.0334	.0339	8.0	8.5	3.2	3.1	2.5	2.3
......	.0250	......	7.5	......	2.5	......	2.0	.0218	......	7.0	......	2.7	......	2.3	......

AUGUST 3

0.0275	0.0484	7.6	9.4	2.8	3.4	1.9	2.4	0.0360	0.0418	8.7	8.6	3.2	3.2	2.1	2.3
.0636	.0639	10.0	10.3	3.7	3.7	2.7	2.7	.0561	.0511	10.0	9.6	3.6	3.6	2.5	2.5
.0634	.0650	10.1	10.0	3.7	3.7	2.7	2.7	.0550	.0532	10.1	10.1	3.5	3.4	2.6	2.5
.0648	.0644	10.1	10.7	3.7	3.6	2.8	2.6	.0580	.0542	10.4	10.1	3.5	3.5	2.6	2.6
.0627	.0650	10.0	10.5	3.7	3.5	2.7	2.7	.0559	.0534	9.8	9.8	3.5	3.4	2.7	2.6
.0606	.0645	9.8	10.6	3.6	3.7	2.7	2.7	.0508	.0440	9.1	9.8	3.4	3.2	2.7	2.5
.0583	.0645	9.4	10.3	3.5	3.7	2.6	2.7	.0476	.0460	9.9	9.7	3.4	3.3	2.6	2.6
.0508	.0614	9.5	10.0	3.6	3.6	2.6	2.7	.0485	.0445	9.7	9.2	3.4	3.3	2.6	2.5
.0508	.0540	9.5	10.1	3.4	3.5	2.6	2.6	.0434	.0425	9.3	9.0	3.3	3.2	2.6	2.5
.0433	.0527	9.0	10.7	3.3	3.4	2.6	2.6	.0419	.0407	9.0	9.5	3.3	3.2	2.6	2.5
.0418	.0505	8.8	9.8	3.2	3.5	2.5	2.6	.0400	.0385	9.3	8.2	3.2	3.2	2.5	2.5
.0428	.0482	9.2	9.4	3.4	3.5	2.6	2.6	.0374	.0362	8.4	8.4	3.2	3.2	2.5	2.3
.0395	.0402	9.0	8.6	3.4	3.3	2.5	2.4	.0315	.0333	8.8	8.1	3.0	3.0	2.2	2.3
.0331	.0390	8.9	8.8	3.1	3.4	2.3	2.5	.0287	.0302	8.2	8.3	3.0	3.0	2.2	2.3
......	.0330	......	8.1	......	3.2	......	2.4	......	.0202	......	6.8	......	2.6	......	1.8
......	.0233	......	7.0	......	2.7	......	2.0								

EFFECT OF REMOVING THE AWNS FROM HANNCHEN BARLEY AT ABERDEEN, IDAHO

Both the material and the conditions were more favorable for satisfactory investigations at Aberdeen than in Minnesota.

The Hannchen is a 2-rowed, awned variety of barley that grows very well under irrigation. The lateral florets are infertile, and this removes the complication of prolonged flowering and the great range of variation which is present when the small lateral kernels are developing. The normal development of Hannchen barley has been discussed in an earlier paper.[1]

The growth under irrigation in Idaho is much more uniform than that in Minnesota. There are few cloudy days and fewer days in which the humidity is at all high. Storms which break the culms are very rare, and diseases which affect the leaves or culms are entirely negligible.

[1] HARLAN, Harry V. OP. CIT.

The samples at Aberdeen consisted of at least two spikes. Just after flowering, when the kernels were small, three spikes were used. In Table IV only two of these are reported because the inclusion of the third makes the table even more cumbersome. In this table the steady growth of the kernel is apparent. Even when not averaged, the maximum kernel weights during the early part of the period constitute a very uniform series. The difference between the clipped and unclipped spikes becomes increasingly apparent as growth progresses.

The average weights and measurements in Table V are more easily studied than are the unsummarized data in Table IV. Table V gives the average by days. In some instances abnormal kernels have been thrown out, because they introduce variations that may as well be excluded. The kernels from the clipped spikes often exceed those of the normal spikes in weight and dimensions during the first week after flowering. As was the case in Minnesota, the normal spikes soon outstrip the clipped ones and maintain their advantage until maturity. The comparative development is illustrated in figures 7 and 8.

TABLE V.—*Average wet weight, length, lateral diameter, and dorsoventral diameter of kernels from normal and clipped spikes of Hannchen barley from flowering to maturity, at Aberdeen, Idaho, in 1916*

UNCLIPPED SPIKES

Date.	Wet weight.	Length.	Lateral diameter.	Dorso-ventral diameter.	Date.	Wet weight.	Length.	Lateral diameter.	Dorso-ventral diameter.
	Mgm.	*Mm.*	*Mm.*	*Mm.*		*Mgm.*	*Mm.*	*Mm.*	*Mm.*
July 10	3.8	3.35	1.37	0.93	July 22	51.2	10.17	3.58	2.52
11	5.8	4.53	1.53	.97	24	57.3	10.27	3.77	2.61
12	7.4	5.58	1.65	1.00	25	56.5	10.16	3.67	2.57
13	14.9	8.74	1.98	1.33	26	60.6	10.22	3.72	2.56
14	16.0	8.87	2.03	1.38	27	58.3	9.79	3.58	2.51
15	21.9	9.57	2.14	1.57	28	60.2	10.05	3.74	2.75
17	37.1	10.31	3.03	2.13	29	65.8	10.00	3.86	2.72
18	41.7	9.99	3.29	2.21	31	64 4	10.16	3.76	2.70
19	42.3	10.01	3.34	2.30	Aug. 1	61.5	9.92	3.75	2.72
20	43.5	10.27	3.34	2.30	2	51.9	9.61	3.47	2.59
21	46.9	10.35	3.51	2.36	3	52.2	9.57	3.47	2.58

CLIPPED SPIKES

Date.	Wet weight.	Length.	Lateral diameter.	Dorso-ventral diameter.	Date.	Wet weight.	Length.	Lateral diameter.	Dorso-ventral diameter.
July 10	3.3	3.00	1.27	0.85	July 22	47.1	9.80	3.47	2.27
11	6.7	5.13	1.55	.97	24	52.9	9.95	3.64	2.45
12	7.8	5.81	1.58	.92	25	52.3	9.99	3.50	2.41
13	13.8	8.28	1.89	1.27	26	57.4	9.98	3.59	2.50
14	18.3	9.41	2.12	1.48	27	52.6	9.66	3.45	2.44
15	21.6	9.46	2.24	1.57	28	55.6	9.72	3.60	2.58
17	31.9	9.49	2.91	1.95	29	59.6	9.71	3.68	2.57
18	36.4	9.71	3.05	2.07	31	56.4	9.73	3.61	2.54
19	37.1	9.56	3.22	2.15	Aug. 1	55.6	9.75	3.62	2.60
20	39.8	10.00	3.21	2.17	2	49.7	9.38	3.42	2.55
21	41.9	9.83	3.36	2.23	3	43.5	9.17	3.27	2.46

The graphs of the growth in length essentially coincide for six days after flowering. For some reason not apparent, the kernels in the normal spikes reach a greater length than those of the clipped spikes. This greater length is still in evidence at maturity. The difference is only ½

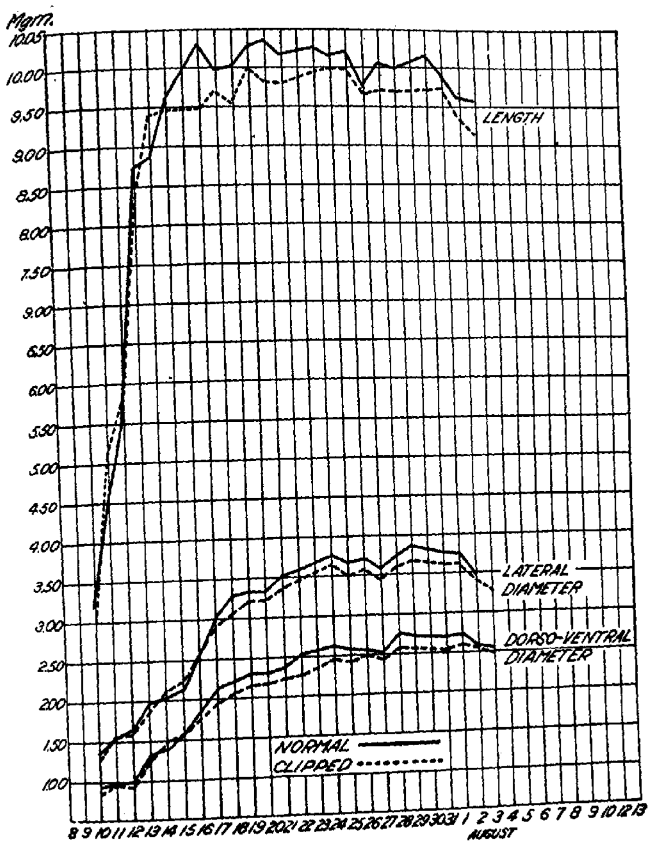

FIG. 7.—Graph showing growth in length, lateral diameter, and dorsoventral diameter of kernels of Hannchen barley in normal and clipped spikes.

mm., but it occurred in both Minnesota and Idaho. A part of the difference seems to have been due to the greater water content of the normal kernels, for the graphs of kernel lengths approach each other again at maturity.

At Aberdeen, the course of the development of the lateral diameter is much like that of the dorsoventral diameter. Seven or eight days after

flowering, the diameters of the normal kernels are larger than those from clipped spikes, and they then continue larger for the remainder of the period of development. In Minnesota, there is little difference between the kernels of the two classes of spikes until near maturity. As maturation approaches, the normal kernels are found to be uniformly greater in diameter than are those from the clipped spikes.

The graph of the wet weight is much more uniform at Aberdeen than at St. Paul. As in Minnesota, there is no difference between the clipped and normal spikes in the first few days. The period of equality is shorter

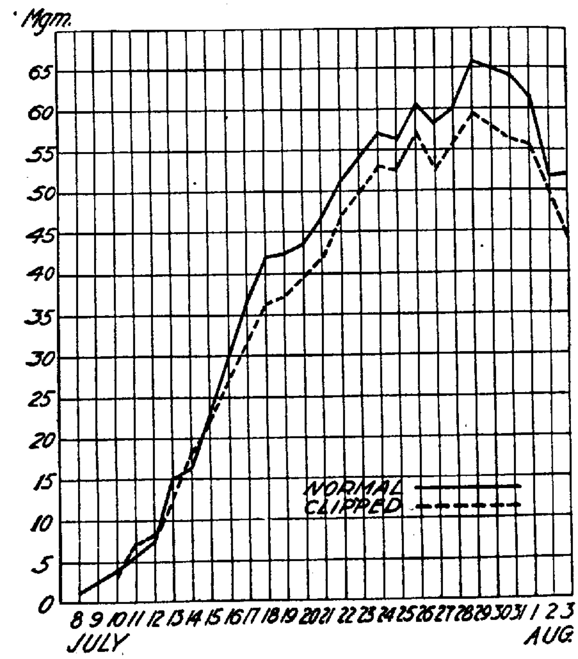

FIG. 8.—Graph showing wet weight of kernels of Hannchen barley from normal and clipped spikes.

at Aberdeen, however. After July 15 the average wet weight of the kernels from clipped spikes here never equals the wet weight of the kernels from normal spikes.

The wet weight includes a variable amount of water, which increases during the first half of the growing period and decreases during the second half. For this reason the curve of the wet weight differs greatly from the curve of the dry weight. The dry weights are shown in figure 9. In Minnesota, the trend of increase in dry weight was quite uniform, as was shown in figure 3. In Idaho, the graph of the dry weight is almost a straight line. It would seem that in both the normal and clipped

spikes the rate of growth was very nearly at its maximum. If this is true, the maximum of the clipped is less than that of the normal spike, for after July 15 the dry matter per kernel is always less.

The percentage and weight per kernel of the dry matter are given in detail in Table VI. This table also includes the data on water, nitrogen,

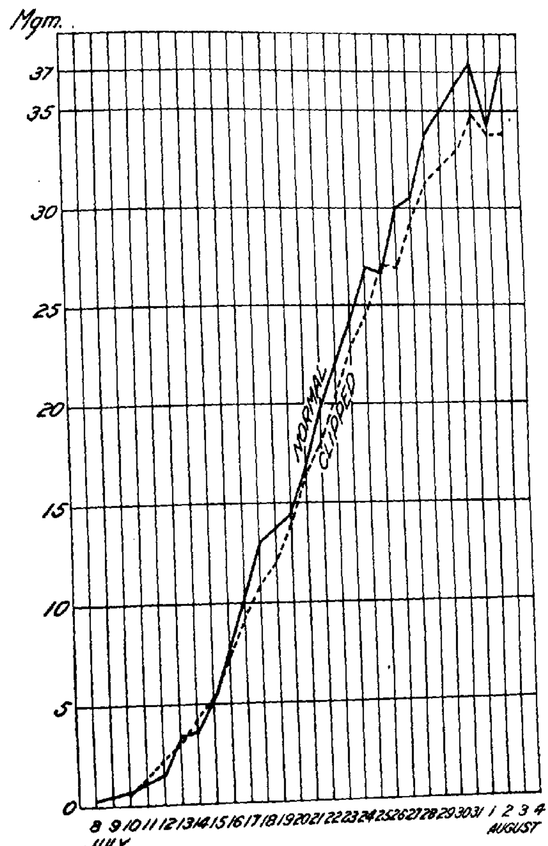

FIG. 9.—Graph showing dry matter in kernels of Hannchen barley from normal and clipped spikes.

and ash. These figures were obtained from the analyses of the samples reported in Tables IV and V. Most of the data on the percentages of the various substances have not been included in the figures. An inspection of the tables shows a surprisingly uniform decrease in the percentage of water and, of course, an equally uniform increase in the percentage of

dry matter. The difference between the percentage of materials present in the kernels of normal and clipped spikes is necessarily in direct relation to the actual quantities.

TABLE VI.—*Average percentage and weight per kernel of dry matter, water, nitrogen, and ash in kernels from normal and clipped spikes of Hannchen barley at Aberdeen, Idaho, in 1916*

NORMAL SPIKES

Date.		Dry matter.	Water.	Nitrogen in dry matter.	Ash in dry matter.	Wet weight per kernel.	Dry weight per kernel.	Water per kernel.	Nitrogen per kernel.	Ash per kernel.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Mgm.*	*Mgm.*	*Mgm.*	*Mgm.*	*Mgm.*
July	8	20. 48	79. 52	....	7. 46	1. 4	0. 3	1. 1	......	0. 02
	10	18. 18	81. 82	7. 33	3. 40	3. 8	. 7	3. 1	0. 05	. 02
	11	19. 23	80. 77	4. 61	4. 21	5. 8	1. 1	4. 7	. 05	. 05
	12	19. 10	80. 90	4. 16	5. 47	7. 4	1. 4	6. 0	. 06	. 08
	13	22. 03	77. 97	3. 56	4. 33	14. 9	3. 3	11. 6	. 12	. 14
	14	22. 76	77. 24	3. 15	3. 74	16. 0	3. 6	12. 4	. 11	. 13
	15	23. 87	76. 13	2. 94	3. 69	21. 9	5. 2	16. 7	. 15	. 19
	17	28. 41	71. 59	2. 33	3. 06	37. 1	10. 5	26. 6	. 24	. 32
	18	31. 06	68. 94	2. 01	3. 21	41. 7	13. 0	28. 7	. 26	. 42
	19	32. 47	67. 53	1. 91	3. 52	42. 3	13. 7	28. 6	. 26	. 48
	20	33. 21	66. 79	1. 80	3. 45	43. 5	14. 4	29. 1	. 26	. 50
	21	36. 21	63. 79	1. 92	2. 87	46. 9	17. 0	29. 9	. 33	. 49
	22	38. 92	61. 08	1. 93	2. 63	51. 2	19. 9	31. 3	. 38	. 52
	24	42. 38	57. 62	1. 97	2. 50	57. 3	24. 3	33. 0	. 48	. 61
	25	47. 59	52. 41	2. 02	2. 56	56. 5	26. 9	29. 6	. 54	. 69
	26	43. 96	56. 04	2. 06	2. 45	60. 6	26. 6	34. 0	. 55	. 65
	27	51. 37	48. 63	1. 83	2. 60	58. 3	29. 9	28. 4	. 55	. 78
	28	50. 69	49. 31	2. 06	2. 35	60. 2	30. 5	29. 7	. 63	. 72
	29	50. 99	49. 01	2. 03	2. 32	65. 8	33. 6	32. 2	. 68	. 78
	31	56. 01	43. 99	2. 33	2. 41	64. 4	36. 1	28. 3	. 84	. 87
Aug.	1	60. 96	39. 04	2. 17	2. 20	61. 5	37. 5	24. 0	. 81	. 83
	2	65. 81	34. 19	2. 07	2. 30	51. 9	34. 2	17. 7	. 71	. 79
	3	71. 91	28. 09	2. 25	2. 25	52. 2	37. 5	14. 7	. 84	. 84

CLIPPED SPIKES

Date.		Dry matter.	Water.	Nitrogen in dry matter.	Ash in dry matter.	Wet weight per kernel.	Dry weight per kernel.	Water per kernel.	Nitrogen per kernel.	Ash per kernel.
July	10	17. 8	82. 2	5. 43	6. 63	3. 3	0. 6	2. 7	0. 03	0. 04
	11	19. 0	81. 0	4. 14	4. 17	6. 7	1. 3	5. 4	. 05	. 05
	12	28. 0	72. 0	3. 73	4. 80	7. 8	2. 2	5. 6	. 08	. 11
	13	21. 6	78. 4	3. 52	4. 28	13. 8	3. 0	10. 8	. 11	. 13
	14	23. 5	76. 5	3. 04	4. 08	18. 3	4. 3	14. 0	. 13	. 18
	15	24. 6	75. 4	2. 56	3. 76	21. 6	5. 3	16. 3	. 14	. 20
	17	29. 2	70. 8	2. 59	3. 36	31. 9	9. 3	22. 6	. 24	. 31
	18	30. 1	69. 9	2. 02	3. 18	36. 4	11. 0	25. 4	. 22	. 35
	19	32. 4	67. 6	2. 00	2. 89	37. 1	12. 0	25. 1	. 24	. 35
	20	35. 3	64. 7	2. 03	3. 00	39. 8	14. 0	25. 8	. 28	. 42
	21	39. 4	60. 6	2. 03	2. 93	41. 9	16. 5	25. 4	. 33	. 48
	22	38. 5	61. 5	1. 90	3. 00	47. 1	18. 1	29. 0	. 34	. 54
	24	43. 3	56. 7	1. 97	2. 69	52. 9	23. 0	29. 9	. 45	. 62
	25	47. 1	52. 9	2. 06	2. 54	52. 3	24. 6	27. 7	. 49	. 62
	26	47. 2	52. 8	2. 06	2. 80	57. 4	27. 1	30. 3	. 56	. 76
	27	51. 2	48. 8	2. 10	2. 45	52. 6	26. 9	25. 7	. 56	. 66
	28	52. 8	47. 2	2. 15	2. 39	55. 6	29. 4	26. 2	. 63	. 70
	29	52. 6	47. 4	2. 15	2. 48	59. 6	31. 3	28. 3	. 67	. 78
	31	58. 4	41. 6	2. 06	2. 08	56. 4	32. 9	23. 5	. 68	. 68
Aug.	1	62. 5	37. 5	2. 17	2. 27	55. 6	34. 8	20. 8	. 76	. 79
	2	67. 9	32. 1	2. 24	2. 31	49. 7	33. 7	16. 0	. 75	. 78
	3	77. 6	22. 4	1. 98	2. 26	43. 5	33. 8	9. 7	. 67	. 76

The ash was determined in more organs at Aberdeen than at St. Paul. The percentage of ash in the rachis, paleae, and awns is shown in figure 10, as well as the ash in the kernel. The analysis of the other structures throws much light on the problem. The awn contains a surprising amount of ash. At flowering time 10 per cent of its dry weight is ash, while at maturity 33 per cent of the dry weight is ash.

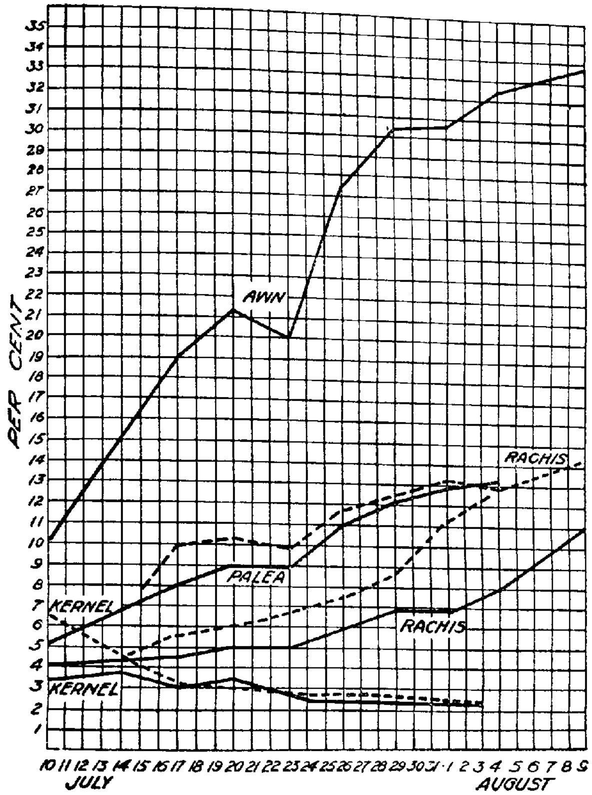

FIG. 10.—Graph showing percentage of ash in the kernels, rachises, paleae, and awns of normal spikes of Hannchen barley and in the kernels, rachises, and paleae of clipped spikes.

The total amount of ash present is considerable. The percentage of ash in the kernels of the clipped spikes is about the same as in those of the normal spikes. The paleae of the clipped spikes contain more ash than those of the normal spikes.

It is in the rachis that the greatest and most significant difference occurs. The rachises of the clipped spikes contain 25 per cent more ash than the rachises of the normal spikes. It would seem that much

of the mineral content that usually goes into the awn remains in the rachis of the clipped spike. These rachises were found to be brittle, while the normal ones were not. Both in Minnesota and in Idaho the clipped spikes had a tendency to shatter, while the normal spikes exhibit

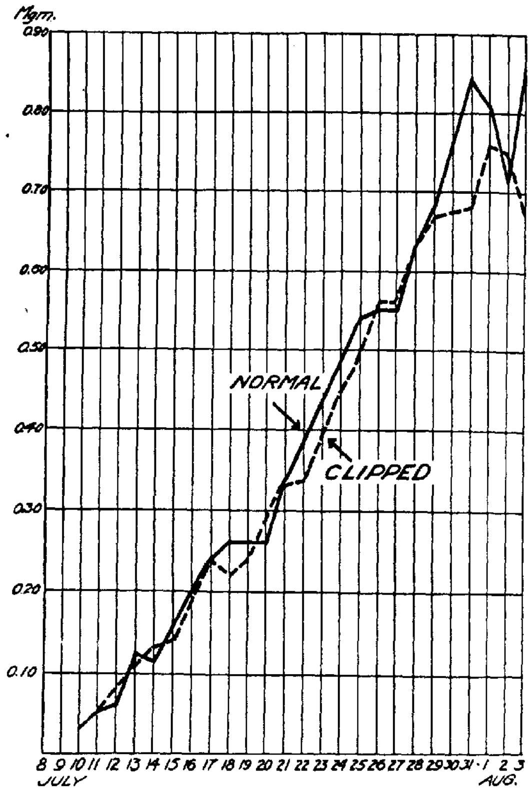

FIG. 11.—Graph showing total nitrogen in kernels of Hannchen barley from normal and clipped spikes.

no such tendency. The divergence in ash content is surprisingly large and widens consistently throughout the period of growth.

The increase in nitrogen per kernel in Idaho is similar to that found in Minnesota. The amount of nitrogen in the kernels from clipped spikes is almost as large as that in the kernels from normal spikes. The average is slightly less, but as a whole the content of nitrogen is nearly equal in the two, as may be seen in figure 11.

The difference in water content shown in figure 12 is more striking at Aberdeen than at Minnesota. After July 15 the kernels from clipped

spikes never contain as much water as those from normal spikes. This is in full accord with the results obtained at St. Paul, but the greater uniformity of the development at Aberdeen emphasizes the difference of behavior by removing the confusion of abnormal samples.

In a preliminary experiment conducted at Arlington Farm, Va., the relation of the length of the awn to the weight of kernel was studied. The awns increase in length from the base of the spike for about one-third the distance to the tip. The spikelets on the upper two-thirds of

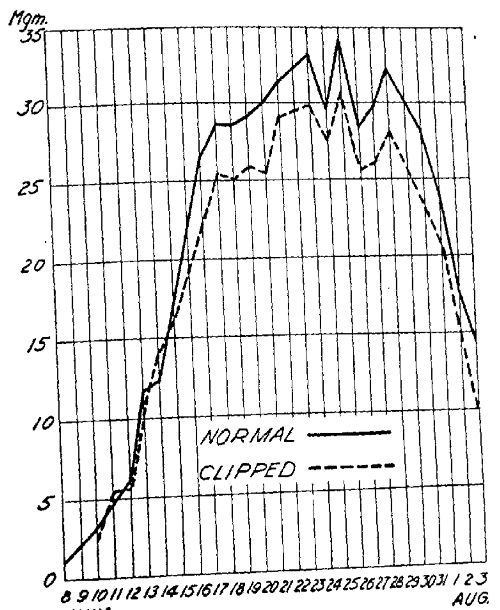

FIG. 12.—Graph showing water in kernels of Hannchen barley from normal and clipped spikes.

the spike exhibit a gradual decrease in awn length, the shorter awn occurring on the apical spikelet.

Figure 13 shows a composite spike resulting from the average of the data obtained. In this case the node numbers include both sides of the spike and are alternate. The weights used are the average of the kernels at two adjacent nodes. It will be seen in the figure that the greatest difference in weight results from the removal of the longest awns. The removal of the short awns near the tip affects the yield only slightly. If the curve of the clipped kernels is taken as showing that the normal peak due to nutrition occurs at about node 9 or 10, the greater length of awn on node 6 is seen to move the peak of the

kernels from awned spikelets nearer to the base of the spike than is the case in the clipped spikelets.

DISCUSSION OF RESULTS

The results in both Minnesota and Idaho have a direct bearing on the two chief field problems in the production of hooded and awnless barleys. These barleys have not yielded as well as the bearded sorts, and they have shattered.

The barleys from which the awns were removed did not give as high yield in these experiments as the awned plants growing beside them. This conforms to the experience of Zoebl and Mikosch, Schmid, Perlitus,

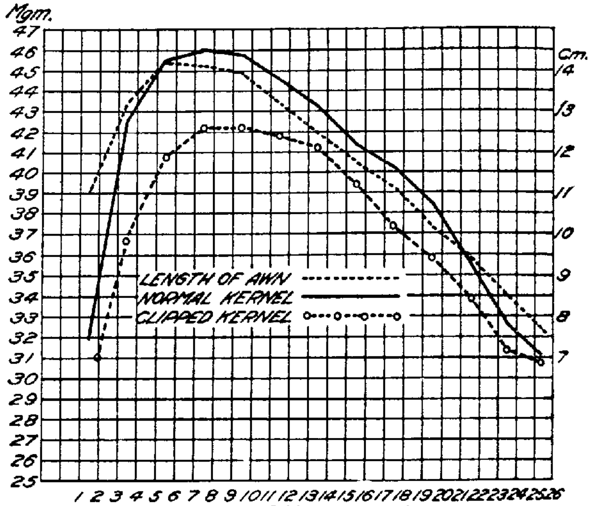

FIG. 13.—Graph showing relation of length of awn to weight of clipped kernels and unclipped spikelets on a 2-rowed barley grown at Arlington Farm, Va.

and some other investigators. In this study it was evident that the reduction in yield was not due to any injury to the plant, as the difference in growth was not apparent for several days after the awns had been removed. The early growth of the kernels in clipped and normal spikes was equally vigorous. It was only when starch infiltration became rapid that the awned spikes showed greater activity. The difference in ultimate weight was largely due to the difference in the quantity of starch present. There was little difference in the quantities of ash and nitrogen. Zoebl and Mikosch looked upon the awn as an organ of transpiration. Whether the reduction of transpiration alone is sufficient to account for the lower rate of starch production is a question. That transpiration has an influence on the behavior of the hooded

barleys is indicated in the field experiments. These barleys have proved relatively better in dry years on the northern plains than in wet years. In the "good" years the hooded varieties have been far inferior to the best bearded sorts, but in "bad" years they often have been better.

In any case, these two experiments show that the awn has a function, and the loss of the awn has resulted in a reduced yield.

The second field problem is that of shattering. The common hooded and awnless varieties have a tendency to shatter at maturity. The clipped spikes of Manchuria and Hannchen barleys showed a tendency in this direction; the normal spikes did not. The spikes from which the awns were removed proved to be fragile, and many of them fell to pieces as maturity approached.

An explanation of this behavior was found in the determination of ash in the awns, rachises, and paleae. The ash that normally went into the awn was deposited largely in the rachis of the clipped spikes. The additional ash seems to have been sufficient to cause the rachis to be brittle. It would seem that the awn also served as a place in which to store the excess of ash. More mineral matter probably is taken up in growth than is needed by the plant. There is no method of elimination. The extra mineral is deposited in cells which probably serve little purpose other than storage. The removal of tissues and organs containing cells which can be devoted to this end must, in itself, cause some derangement of the normal processes of development.

From the experiments conducted, it would seem that awnless and hooded barleys are limited by the loss of the awns. It appears that high yields are not to be expected from such varieties. It is to be expected that such sorts will shatter more than awned kinds. This has been the experience in breeding also. For the most part awnless hybrids have been brittle and of low yielding capacity. It is thought that there is little use in attempting to secure valuable awnless or hooded varieties by means of hybrids with most varieties. One possible method of breeding has been indicated by experiments not yet published. Some varieties of awned barley have normally a much lower content of ash in the rachis than others. It is possible that the progeny of crosses with these and the hooded sorts may yield well in semiarid climates and that they will not shatter. One or two such hybrids are now giving promise.

When the first elementary experiment conducted in Minnesota indicated the physiological difficulties in the way of producing desirable varieties of hooded and awnless barleys, work was amplified in another line. Several hundred hybrids with smooth awns have been produced and tested. Much of this work has been done in the cooperative experiments with the Minnesota Agricultural Experiment Station, but many strains have been tried elsewhere. Several of these give promise of good yielding capacity.

The awns of these hybrids are smooth. All the large scabrous teeth on the basal two-thirds of the awn have been eliminated. The tips of the awns are slightly rough, but this roughness is not sufficient to be objectionable to either growers or feeders of barley. Whether varieties of this type can be made to yield equally as well as the awned sorts remains to be determined.

SUMMARY

The removal of the awns from a barley spike has a marked effect on the development of the kernels of the spike.

Kernels from clipped spikes have smaller volume and a lower weight of dry matter at maturity than do those from normal spikes.

The difference is not due to the injury or shock of removing the awns; the kernels in the clipped spikes develop as rapidly as those in the normal spikes for several days after the awns are clipped.

About one week after flowering the deposit of dry matter in the kernels of the normal spikes begins to exceed that in the kernels of the clipped spikes. This is about the time that rapid starch infiltration begins.

The daily deposit of nitrogen and ash is more nearly equal in the two classes of spikes than is the deposit of starch.

In normal spikes at Aberdeen, Idaho, the awns contained more than 30 per cent of ash at maturity. When the awns were removed a part of this ash apparently was deposited in the rachis. The rachises of the clipped spikes contained about 25 per cent more ash than the rachises of the normal spikes.

The additional ash in the rachises of the clipped spikes probably was responsible for the tendency of these spikes to break. The indications are that the elimination of the awns results not only in lower yields but in shattering as well.

Hooded and awnless barleys generally yield less and shatter more than awned varieties, and there seem to be physiological reasons for this fact.

It may be possible to produce nonshattering hooded and awnless sorts by using parents which normally have a low percentage of ash in the rachises. It may be possible to obtain strains that will give good yields under arid conditions. Under humid conditions it is likely that the objections to the awns are more easily met by the use of strains with smooth awns, which, so far as known at present, have no physiological limitations.